TEST EDITION

THE TEXTBOOK OF

BIOLOGY

For Grade 10

SINDH TEXTBOOK BOARD, JAMSHORO

THE TEXTBOOK OF BIOLOGY FOR CLASS 10

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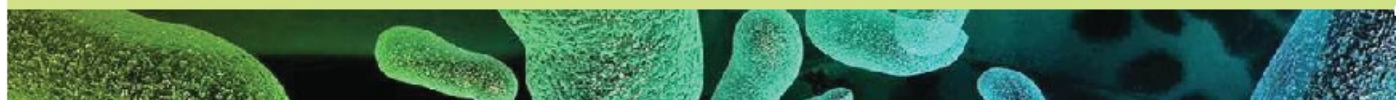
Sindh Textbook Board, Jamshoro

Prepared by **Association For Academic Quality (AFAQ)** for **Sindh Text Book Board**
Reviewed by **Directorate of Curriculum Assessment and Research Sindh, Jamshoro**
Prescribed by the Board of Intermediate and Secondary Education Hyderabad, Sukkur, Shaheed Benazirabad, Larkana, Mirpurkhas and Karachi for Secondary School Examination.
Approved by the **Education and Literacy Department, Government of Sindh.**
No.SO(C) SELD/STBB-18/2021 Dated: 14th July, 2021 for the province of Sindh

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PREFACE

The century we have stepped in, is the century of Biology. The modern disciplines Biology are strongly influencing not only all the branches of science but each and every aspect human life.

To keep the students. abreast with the recent knowledge, it is a must that the curricula, at all the levels, be updated regularly by introducing the rapid and multidirectional development taking place in all the branches of Biology.

The recent book of Biology for class X has been written in this preview and in accordance with the revised curriculum prepared by Ministry of Education, Govt of Pakistan, Islamabad reviewed by independent team of Bureau of Curriculum, Jamshoro sindh. Keeping in view of the importance of Biology, the topics have been revised and re-written according to the need of the time.

Since long Biology was teaching only in IX class, the text book was consits of 19 chapters which was unable to complete in working hours. it has been decided now the Biology syllabus will be divided into portions, one should teach in 9th class and other will teach 10th class. So this book is consist of 9 chapters which have been thoroughly revised and re-written to meet the requirement of the curriculum. Special emphasis has also been paid to the applied aspect including the biological problems of daily life. Attention has also been focused on the causes and preventive measures of the common disorders of the human body. Being agriculture country, the agriculture aspects and problems of country are also discussed.

Among the new editions are the introductory paragraphs, information boxes, summaries and a variety of extensive exercises which I think will not only develop the interest but also add a lot to the utility of the book.

The Sind Textbook Board has taken great pains and incurred expenditure in publishing this book inspite to its limitations. A textbook is indeed not the last word and there is always room for improvement. While the authors have tried their level best to make the most suitable presentation, both in terms of concept and treatment, there may still have some deficiencies and omissions. Learned teachers and worthy students are, therefore, requested to be kind enough to point out the short comings of the text or diagrams and to communicate their suggestions and objections for the improvement of the next edition of this book.

In the end, I am thankful to Association For Academic Quality (AFAQ) our learned authors, editors and specialist of Board for their relentless service rendered for the cause of education.

Chairman
Sindh Textbook Board, Jamshoro

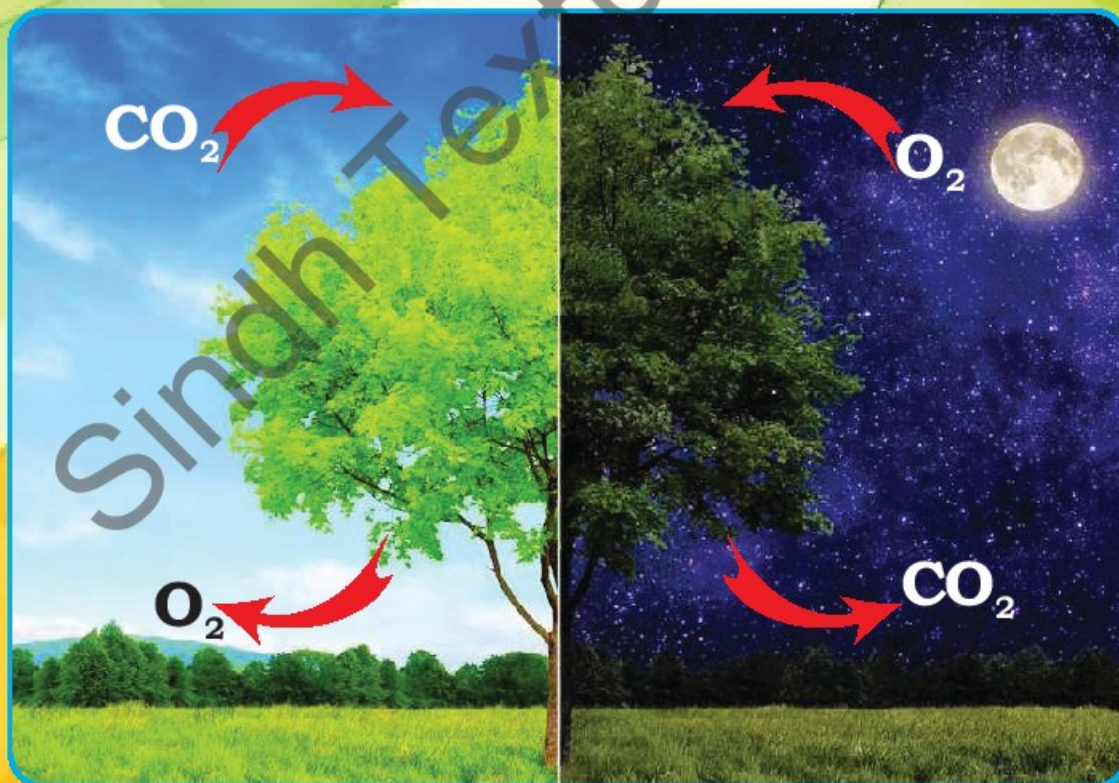
CONTENTS

Chapter 1

GASEOUS EXCHANGE

Major Concept

In this Unit you will learn:

- Introduction
- Gaseous Exchange in Animals
- Gaseous Exchange in Plants
- Gaseous Exchange in Man
  - Air Passage Way and Lungs
  - Mechanism of Breathing
  - Respiratory Disorders and their Causes (Asthma, Bronchitis, Pneumonia, Lung Cancer)
- Effects of Smoking

1.1 INTRODUCTION:

All living organisms must need to exchange oxygen and carbon dioxide gases with their environment to carry out their vital functions such as respiration. In addition to respiration, photoautotrophs like plants do carry out gaseous exchange for the process of photosynthesis. Aquatic organisms exchange gases with water while terrestrial ones with air.

1.2 GASEOUS EXCHANGE IN PLANTS

As stated above, plants exchange gases for the processes of photosynthesis and respiration.

During the process of photosynthesis, carbon dioxide is taken in while oxygen is given out whereas in respiration, oxygen is taken in and carbon dioxide is given out. During daytime, green parts of the plants carry out the process of Photosynthesis to prepare complex food molecules (organic molecules) by utilizing simple molecules such as carbon dioxide gas and water. During this process, carbon dioxide gas is taken in while oxygen gas released as by-product is given out. Respiration on the other hand, takes place in all living cells. It is the process in which food is oxidized to release energy. In aerobic respiration, it involves taking in of oxygen and given out of carbon dioxide. The process of exchange of gases in plants takes place mainly through minute openings called stomata present in leaves. The roots and stem do exchange gases for respiration.

Photosynthesis	Respiration
1. Anabolic process.	1. Catabolic process.
2. Synthesis of food from simple, inorganic substances.	2. Breaking down of food into inorganic substances.
3. Requires light energy.	3. Does not require light energy.
4. Occurs in plants.	4. Occurs in all living organisms.
5. Uses carbon dioxide gas.	5. Uses oxygen gas.
6. Releases oxygen gas.	6. Releases carbon dioxide gas.
7. Takes place during day-time.	7. Takes place all the times.
8. Chlorophyll is required.	8. Chlorophyll not required.

Stomata: (Singular Stoma means mouth)

These are microscopic openings present in the epidermis of leaves. Through these openings, plants exchange gases with their environment. Each stoma is a slit like opening formed by two special cells called **guard cells**. They are chlorophyll containing cells with thicker inner while thinner and elastic outer cell walls. The opening and closing of stomata depends upon turgidity of the guard cells. During daytime, as a result of ongoing process of photosynthesis, the accumulation of photosynthetic solutes causes increase in turgidity of the guard cells. Thus stomata are opened and the process of taking in of carbon dioxide and giving out of oxygen begins until it becomes dark.

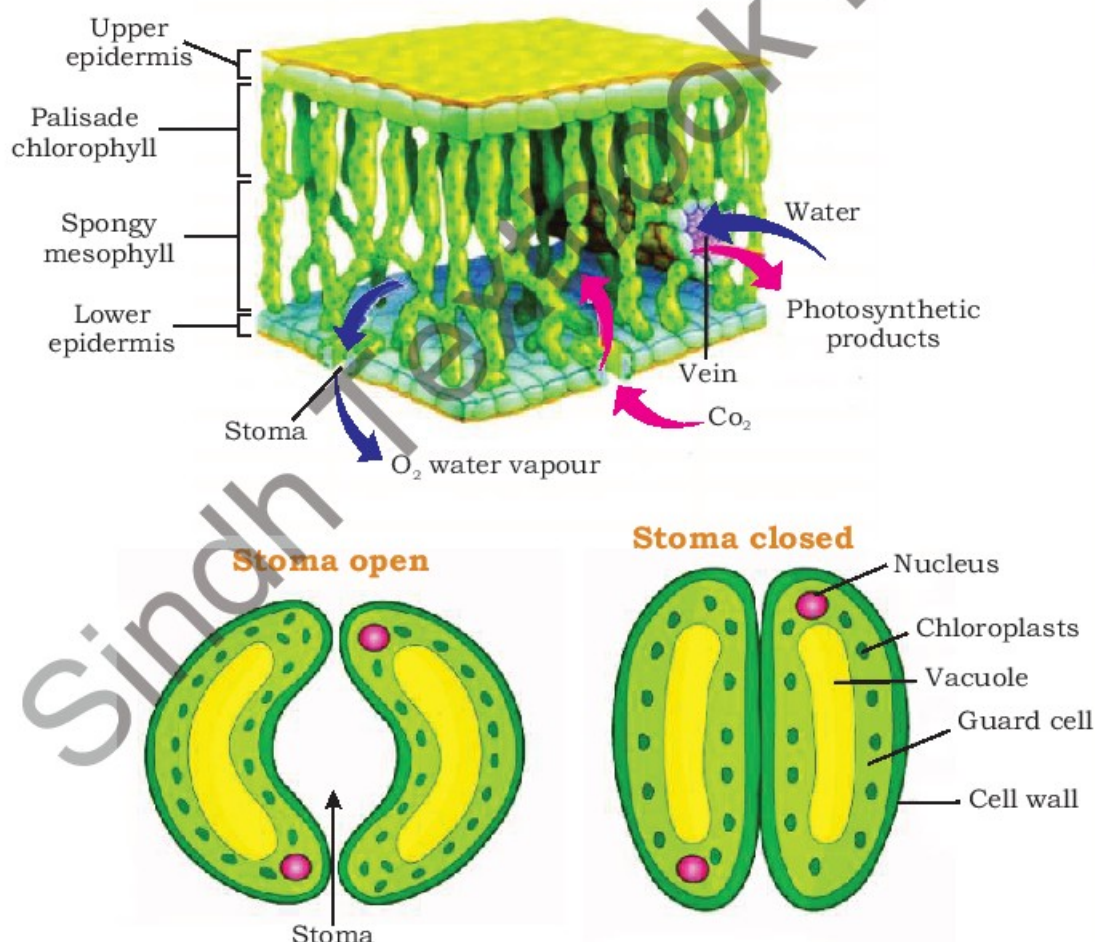



Fig. 1.1 Gaseous Exchange

PRACTICAL ACTIVITY

The effect of light on the net gaseous exchange from leaf by using Hydrogen bicarbonate as indicator.

Hydrogen bicarbonate is an indicator for carbon dioxide. Its colour turns as follows according to the level of carbon dioxide:

Photosynthesis	Respiration
Highest	Yellow
High	Orange
Atmospheric level	Red
Low	Magenta
Lowest	Purple

Requirements:

Four test tubes, test tube stand, aluminum foils or black paper, tissue paper, fresh green leaves, four corks, wax, thread, glass marking pencil

Steps:

1. Mark test tubes as 1, 2, 3 and 4.
2. Fill each test tube quarter full with Hydrogen bicarbonate indicator.
3. Attach each leaf with separate thread and hang one into the test tube 1, test tube 2 and test tube 4 into 3.
4. Plug all the tubes with corks and seal them with wax.
5. Wrap tube 2 with aluminum foil or black paper from all side so that light cannot penetrate into this test tube. Similarly wrap test tube 3 with tissue paper.
6. Place all tubes on stand and put the stand in well lighted place.

7. Note and record your observations given below in the table by tick marking the right in the following table:

	Test Tube 1	Test Tube 2	Test Tube 3	Test Tube 4
Light on	Yes/No	Yes/No	Yes/No	Yes/No
Leaf present	Yes/No	Yes/No	Yes/No	Yes/No
Foil on Tube	Yes/No	Yes/No	Yes/No	Yes/No
Indicator color after an hour	Yellow/ Orange/ Red/ Magenta/ Purple	Yellow/ Orange/ Red/ Magenta/ Purple	Yellow/ Orange/ Red/ Magenta/ Purple	Yellow/ Orange/ Red/ Magenta/ Purple
Carbon dioxide concentration	Highest/ High/ Normal/ low/ lowest	Highest/ High/ Normal/ low/ lowest	Highest/ High/ Normal/ low/ lowest	Highest/ High/ Normal/ low/ lowest
Respiration	Yes/No	Yes/No	Yes/No	Yes/No
Photosynthesis	Yes/No	Yes/No	Yes/No	Yes/No

Critical Thinking:

Q1. Is there any change of coloration of Hydrogen bicarbonate indicator?

Q2. What account for these changes?

1.3 GASEOUS EXCHANGE IN ANIMALS

Like plants, animals do exchange gases with their environment for the respiration process. In order to obtain energy from food, they take in oxygen and give out carbon dioxide. So the process of gaseous exchange is ultimately linked with the respiration.

The respiratory medium for aquatic animals is water whereas for terrestrial animals is air. The amount of molecular oxygen present in air is about 21% while in water it is about 5%. In order to exchange gases, animals have a respiratory surface. In unicellular organisms like Protozoa, the plasma membrane serves as the respiratory surface. In multicellular animals, their body surface or some internal surface could serve as the respiratory surface.

Properties of Respiratory surface:

1) Thin, 2) Wet, 3) Permeable, 4) large in relation to the volume of the body.

Proportion of Respiratory surface:

It must be sufficiently large enough to exchange gases for all the cells of the body. For example, the total surface area of the respiratory surface in human is about 20 times to the size of the body.

Respiratory Surfaces

Large surface area:

☞ An increase surface for gaseous exchange allows a faster rate of diffusion to supply oxygen and remove carbon dioxide. It is also necessary to compensate for the small surface area to volume ration of the animal body.

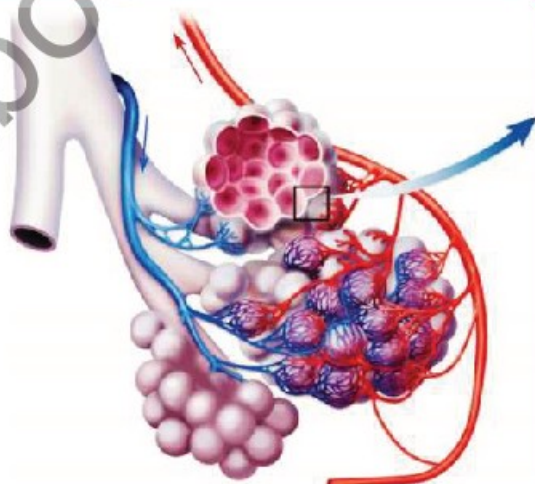



Fig. 1.2 Respiratory Surfaces

1.4 GASEOUS EXCHANGE IN HUMAN

In human, the process of respiration involves breathing, gaseous exchange and cellular respiration. Like other terrestrial vertebrates, our respiratory surface is located inside the body in the form of alveoli contained in paired organs, **lungs**.

1.4.1 Human Respiratory System:

Our respiratory system consists of paired lungs located inside the thoracic (chest) cavity and Air passage ways.

LUNGS:

Each lung is soft, spongy and pinkish in appearance. It is wrapped in two **Pleural membranes**. The space between pleural membranes is filled with fluid that acts like a lubricant. This makes the breathing movements easier. Lungs are enclosed in a bony cage made up of a flat sternum in front, 12 pairs of ribs from front to back where vertebral column is present. Ribs are attached with intercostals muscles. In the lower part of thorax, lies a sheet of muscles called **Diaphragm** which separates it from abdominal cavity. Each lung is made up of millions of **alveoli**.

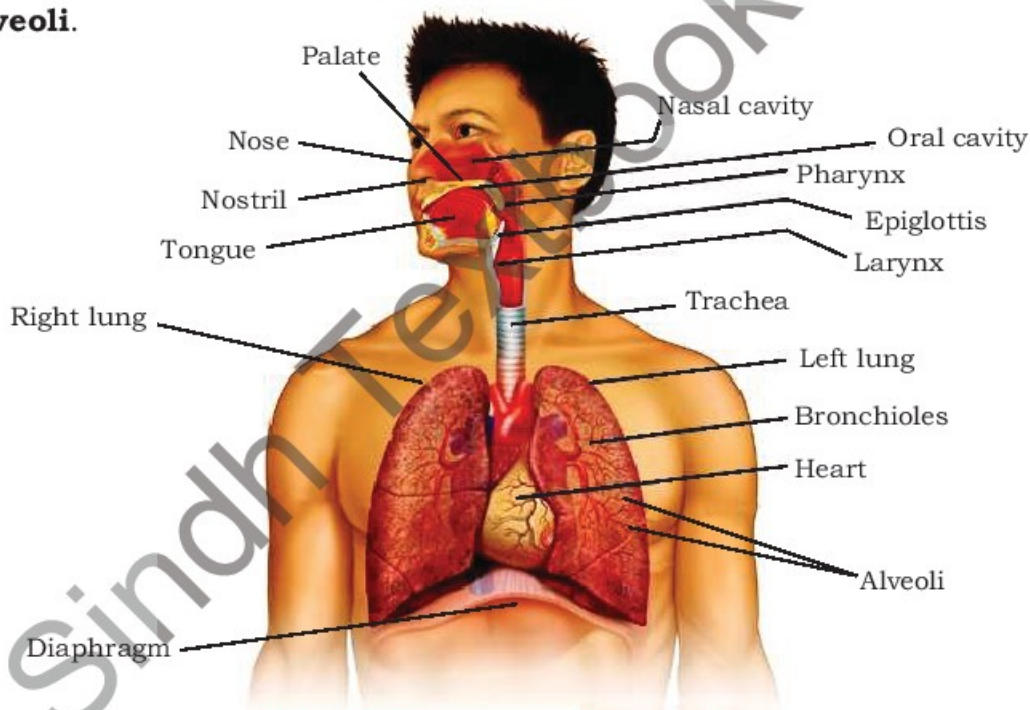
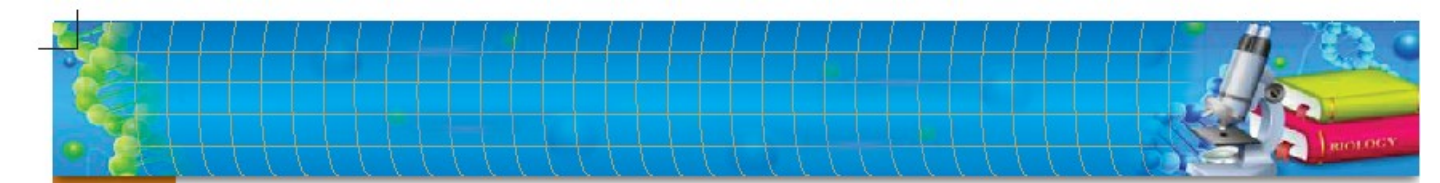



Fig. 1.3 Human respiratory system

Each alveolus is the respiratory surface. It's a pouch like microscopic structure made up of only one layer of cells. It is enclosed by a dense capillary network. In each alveolus, exchange of gases takes place between air and blood. The Air passage ways consists of Nostrils, Trachea,

Bronchi and Bronchioles. Air from outside enters into the nasal sacs through external nostrils. This entire passage through which air passes is lined by mucous secreting ciliated cells. The internal surface has rich blood capillaries which turn the incoming air slightly hot. The hairs in nasal sacs as well as ciliated epithelial lining and mucous keep the air clean by trapping and removing dust and germs. This ensures clean air to approach the respiratory surface.

Trachea:

The internal opening of nasal sacs opens into a long tube, **Trachea**. In its beginning, there is a box like **larynx** or sound box containing vocal cords to produce sound. The opening of larynx is known as **glottis** which has a lid like cover, **epiglottis**. During swallowing food or drink, the epiglottis closes the glottis to prevent any food to enter into the trachea. Trachea has C-shaped cartilaginous rings which prevent it from collapsing.

Bronchi:

Trachea in the center of the thorax bifurcates into two smaller ducts or Bronchi. Each bronchus do have C-shaped cartilaginous rings. Bronchus of each side enters into the respective lung. As soon as it enters into the lung, it breaks up into many smaller ducts or Bronchioles.

Bronchiole:

Each bronchiole is very thin tube that opens into **air sacs** or **alveoli**.

1.4.2 Process of Breathing:

Since the respiratory surfaces are located deep inside the body in the lungs. So in order to perform exchange of gases, the air must first be brought into the lungs from the atmosphere. It is achieved through the process of breathing or Ventilation. The process of breathing consists of two phases, viz., Inspiration and expiration.

LUNG CAPACITY: Like a balloon, lungs can be filled with a maximum amount of 5 liters of air. Surprisingly, we use normally about ½ liter of the air coming into the lungs.

Inspiration:

It is the process through which atmospheric air is directed through the air passage ways up to the alveoli in the lungs. It involves contraction of intercostals muscles and diaphragm. As a result, the volume of thorax (chest) is increased thereby decreasing the pressure of air in lungs. So the external air rushes inside from high pressure to low pressure. The lungs get expanded in this way.

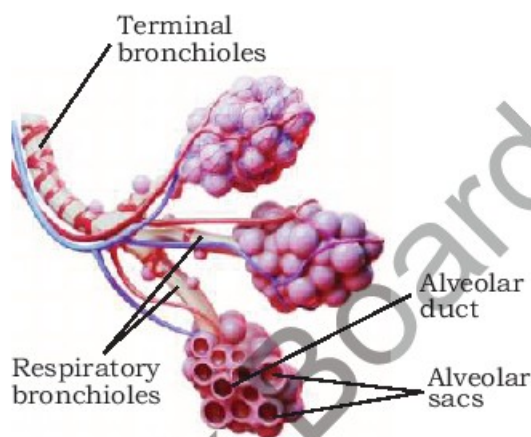



Fig. 1.4 Inspiration

Expiration:

It is just reverse of inspiration. During this process the air moves out from the lungs. Both, intercostals muscles and diaphragm are relaxed. This moves the ribs inside and diaphragm becomes flat. Both the activities depress the chest inside. The volume of thoracic cavity (chest) is decreased causing an increase upon the pressure on lungs. This forces the air present in lungs to outside through the body.

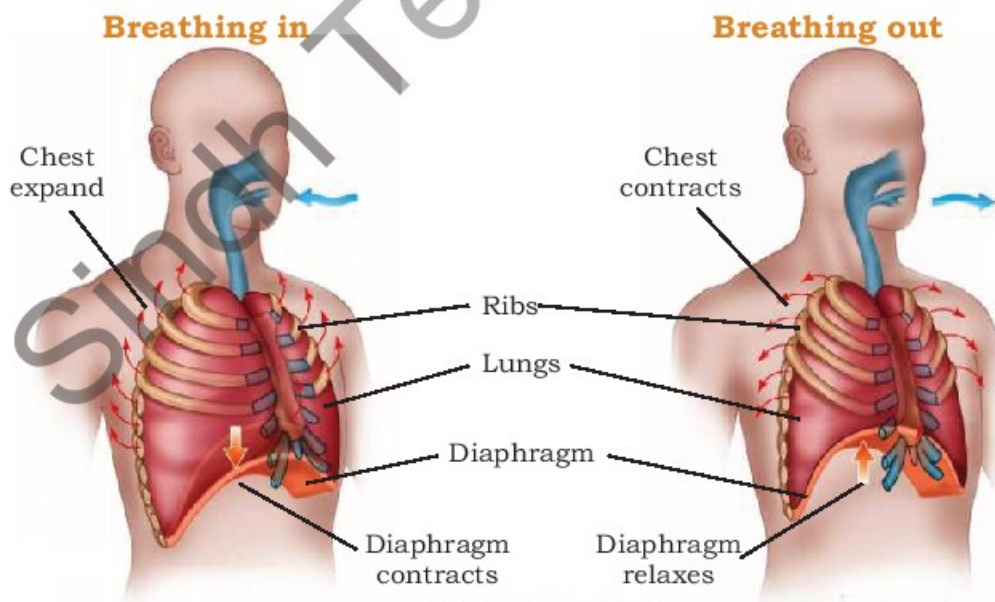



Fig. 1.5 Expiration

1.5 GASEOUS EXCHANGE IN ALVEOLI:

The gaseous exchange takes place at the level of alveoli. Oxygen brought in by air is taken up by the hemoglobin of RBCs of blood and vice versa the carbon dioxide brought by the blood is given out to the air present in alveoli. This gaseous exchange involves diffusion which becomes possible at this level because both alveolus and blood capillaries, are only one cell layered in thickness.

10.5.1 Composition of Inspired and Expired Air:

Components (%)	Inspired air (%)	Expired air (%)
Oxygen	About 21	About 16
Carbon dioxide	About 0.03	About 4
Nitrogen	About 79	About 79
Water Vapour	Variable	saturated
Temperature	Atmospheric temperature	37 degree celsius

Table 10.1 Composition if Inspired and Expired air

(A)
Air being into lime water

(B)
Air being passed into lime water with a syringe

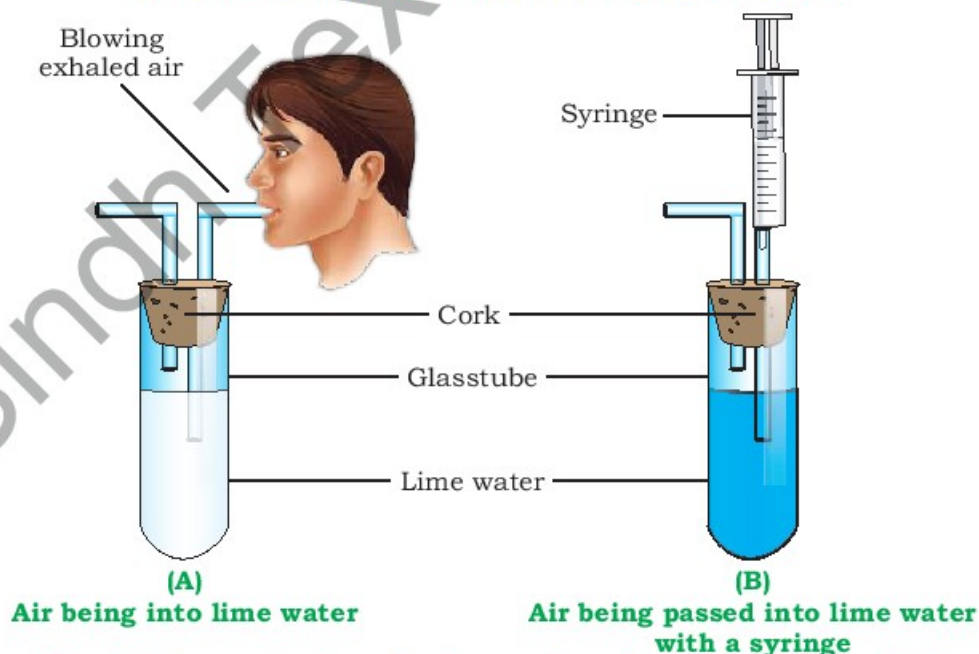



Fig. 1.6 Demonstration of release carbon dioxide during expiration

Carbon dioxide if passed through limewater turns it milky. This is evident through experiment (A) when one exhales air through the lime-water containing apparatus, the lime water turns milky. In (B) if atmospheric air is passed through the lime-water, the later remains unchanged.

10.5.2 Rate of Breathing at Rest and During Exercise:

Breathing is largely an involuntary process. It is regulated by hypothalamus of our brain. The rate of breathing changes automatically according to the changes in internal or external conditions. For instance, if a person is doing exercise, its rate of breathing would increase because of increased consumption of oxygen by his muscles. Thus gradually increase in concentration of carbon dioxide in his blood will cause an increase his breathing rate. If the exercise condition persists, the muscle cells will start breaking down Glucose without oxygen. It is termed as **"anaerobic respiration"**. As a result of this, lactic acid is formed in the muscles rather than carbon dioxide. It causes pain and cramp in normal muscles. The breaking down of lactic acid requires additional amount of oxygen which is termed as "oxygen debt". The extra amount of oxygen is obtained through deep breathes.

Artificial Ventilator:

A machine that works like lungs when patient's natural breathing becomes difficult. Through this machine, the oxygen rich air is directly supplied to the trachea through a tube inserted the mouth upto the wind pipe.

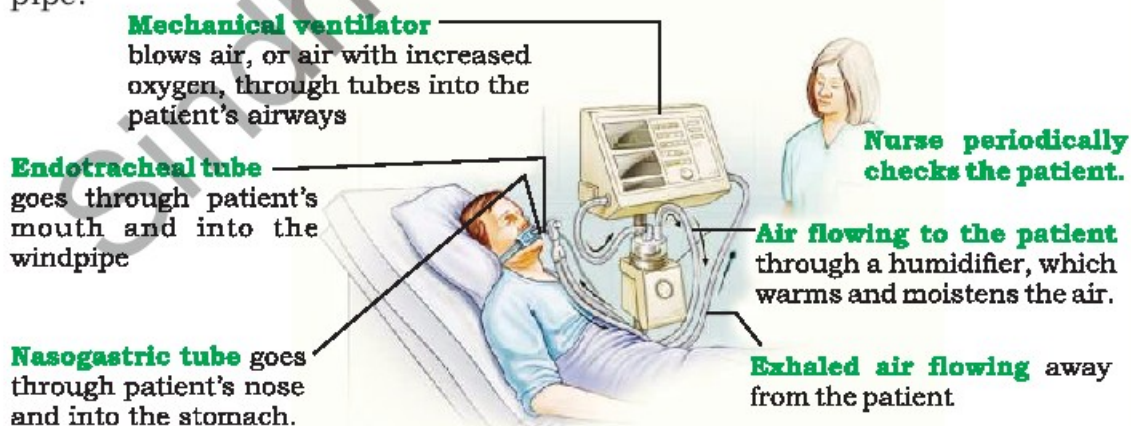



Fig. 1.7 Artificial ventilator

1.6 RESPIRATORY DISORDERS:

Bronchitis:

The inflammation of the air passage ways is termed as **Bronchitis**. It is caused either by smoking or by some bacteria. It is characterized by cough, increased mucous secretion, shortness of breath and low fever.

Emphysema:

It is related to the progressive destruction to the alveoli due to long term exposure usually to the industrial pollutants. It is characterized by laborious breathing. It causes cough with phlegm production.

Pneumonia:

It is an infectious disease usually caused by special bacteria, viruses or fungi. In pneumonia, the alveoli are infected so they may be filled with fluid or pus. The breathing becomes difficult. The patient suffers from fever, cough, chill and chest pain.

Asthma:

It is an inflammatory condition of air-ways of lungs. It is characterized by shortness of breath, chest pain, fever, wheezing sound during expiration and cough. Asthma is actually an allergic response to pollens, dust, smoke, fur, feathers and number of other substances. It may obstruct the air-ways making it difficult to breath for its patient.

Lung Cancer:

Lung cancer is usually associated with smoking. Due to smoke or air pollution, abnormal cells appear in lungs which may spread to other tissues. The major signs and symptoms are cough with blood, shortness of breath, repeated lung infections, weight loss, bone ache, hoarseness, weakness, fatigue, etc.

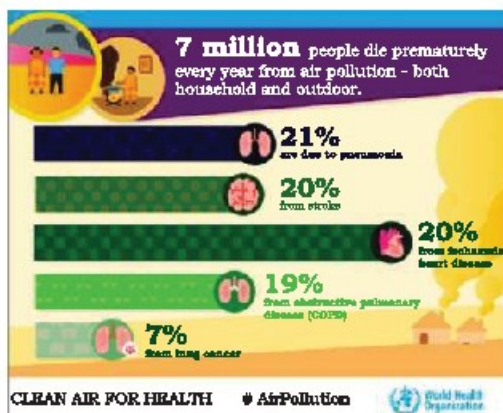
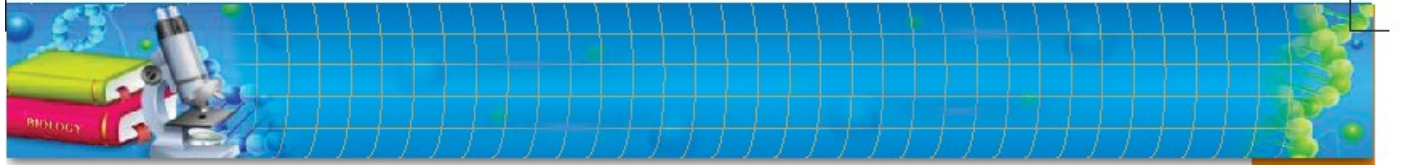



Fig. 1.8
Deaths linked to air pollution

SUMMARY

- Respiration and photosynthesis require exchange of gases.
- Respiration takes place in all living organisms.
- Photosynthesis occurs in green parts of plants.
- During respiration, oxygen is used and carbon dioxide is given out while in photosynthesis, carbon dioxide is used and oxygen is given out.
- In terrestrial plants, most of the exchange of gases occurs through minute openings, stomata.
- The animals use either their body surface, or some internal surface for the exchange of gases.
- Respiratory surface must be thin, wet, permeable and large in relation to the volume of organism.
- The respiratory surface of man is alveoli present in lungs.
- Both lungs have millions of alveoli.
- Air passage ways lead the atmospheric air to alveoli.
- Air pollution causes number of respiratory problems.
- Clean air is essential for better respiratory health.

EXERCISE

A. MULTIPLE CHOICE QUESTIONS

Choose the correct answer:

i) The biological functions which perform gaseous exchange:
(a) Photosynthesis (b) Respiration
(c) Both a & b (d) Growth

ii) Plants do exchange of gases through:
(a) Roots (b) Stomata
(c) Stem (d) All of these

iii) Each stoma is formed by:
(a) one guard cell (b) two guards cells
(c) three guard cells (d) four guard cells

iv) Respiratory surface possesses following property:
(a) thin and wet (b) permeable
(c) very large (d) all of these

v) Inspiration involves:
(a) Contraction of intercostals muscles
(b) contraction of diaphragm
(c) Inward movement of ribs
(d) Both a & b

vi) Larynx is located on:
(a) Lungs (b) Trachea
(c) Bronchus (d) Bronchiole

vii) The respiratory surface of human is:
(a) Nostril (b) Bronchiole
(c) Alveoli (d) Trachea

viii) Increase in rate of breathing is due to the following:
(a) increase CO_2 in blood (b) Increase O_2 in blood
(c) decrease CO_2 in blood (d) decrease O_2 in blood

ix) Which of the following disorder is associated with degeneration of alveoli?

(a) Bronchitis (b) Lung cancer
(c) Asthma (d) Emphysema

x) Which of the following disorder is associated with inflammation of air passage ways?

(a) Bronchitis (b) Lung cancer
(c) Asthma (d) Emphysema

B. SHORT QUESTIONS:

i) Why the stomata generally open during day-time?

ii) Which parts of the plant intake CO_2 and give out O_2 , take in O_2 oxygen and give out CO_2 during day-time?

iii) Why do we have to breathe through nostrils rather than oral cavity?

iv) Differentiate between breathing, gaseous exchange and respiration.

v) Why do we deep breath during or immediately after exercise?

vi) What is "oxygen debt"?

vii) Distinguish between inspiration and expiration.

viii) What is lung cancer?

ix) How the asthma is characterized?

x) Name five animals which use their body surface for gaseous exchange.

C. EXTENSIVE RESPONSE QUESTIONS:

i) What measures would you take to avoid respiratory disorders?

ii) Discuss human respiratory system with the help of suitable illustrations.

iii) Prove with the help of experiment that CO_2 is released during respiration.

iv) Explain the process of ventilation in man.

v) Why smoking is dangerous? How it is related with respiratory disorders?

Chapter 2

HOMEOSTASIS

Major Concept

In this Unit you will learn:

- Introduction
- Homeostasis in Plants
- Homeostasis in Man
- Homeostasis in Animals
- Urinary system of Man
  - ★ Structure and Functioning of Human Kidney
  - ★ Structure of Kidney
  - ★ Structure of Nephron
  - ★ Functioning of Nephron
- Disorders of Human Excretory System
- Kidney Stones and Treatment

2.1 INTRODUCTION

The internal conditions of an organism is referred its internal environment it includes H_2O quantity, different solutes, temperature, etc. For proper metabolic functions body requires all these conditions at particular level. So homeostasis is set of metabolism which maintain internal environment of an organism within suitable limits. Why should the internal environment remain constant? Let's take the example of temperature, the temperature of external environment continuously change during the day but the enzymes work within a certain range of temperature therefore, the living organisms must keep their internal temperature within this range. Organisms maintain internal condition by feedback mechanism. How body maintain homeostasis by feedback mechanism.

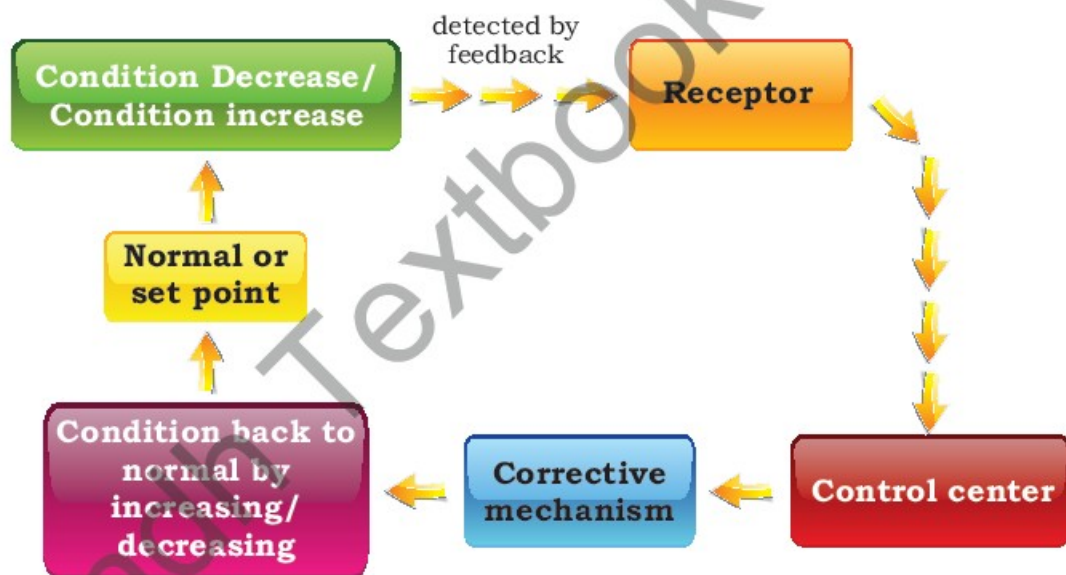



Fig. 2.1 Homeostasis by feed-back

2.2 ADAPTATION OF PLANT FOR DIFFERENT INTERNAL CONDITION

There are three main aspect of homeostasis

(i) Osmoregulation:

It is the maintenance of internal water and salt conditions by osmosis.

(ii) Thermoregulation:

The maintenance of temperature within suitable limits where enzymes can work optimumly.

iii) Excretion:

The process where metabolic toxic waste or excess metabolic substances from body i.e NH_3,urea or uric acid, gums, latex etc.

2.2.1 Excretion or Storage of CO_2

At daytime plant perform photosynthesis in green cells and respiration in all living cells. The CO_2 produced in respiration utilized in photosynthesis. When rate of photosynthesis will be higher than respiration the plant gets extra CO_2 from air and release extra O_2 in air through stomata. At night plant only perform respiration only CO_2 is produced which is removed by the process of diffusion through body surface. The green parts perform these gases exchange through stomata while non green parts perform this gaseous exchange through body surface.

2.2.2 Removal of Extra Water

The plant store large amount of water this water can be removed from plant in two ways i.e.

(a) Transpiration

(b) Guttation

Transpiration is the removal of water in the form of vapours from aerial part of plant. It occurs only at day time.

Guttation is the removal of water in the form of liquid from the margin of leaves through special pores, hydathodes. It only occurs at night when water pressure is high in leaves and low temperature environment is present.

Plants modify their leaves size, structure and structure of stomata to control the rate of transpiration.

Fig. 2.2 Showing Guttation in Leaf

Plants produce some secondary products like latex, resin and gum. These secondary products are insoluble, harmless compounds. Some plants produce special types of gums for example Neem or keeker etc. The extra amount of these are removed from special pores called **lenticels**. The coniferous plants produce resins like material while the rubber plants produce latex which remove from scare like openings. Some of these carnivorous plants and okra produce mucilaginous material to capture insects.

2.2.3. Osmotic adjustment in plants

The plants grow in different conditions of water and salts, on the basis of water and salt quantity there are four type of plants

(a) Hydrophytes
(b) Halophytes
(c) Mesophytes
(d) Xerophytes

(a) Hydrophytes (hydro = water; phyta = plants)

The plant which grow in fresh water; they live completely or partially in fresh water so called totally or partially submerged plants. They adapt themselves for removal of excess water which can enter in this condition.

- These plants do not contain roots or have poorly developed roots.
- They have broad leaves if partially submerged and have stomata at upper epidermis e.g water lilly.
- They may have thin and spongy tissues in leaves and stem in totally submerged plant e.g Hydrilla.

Fig. 2.3 Hydrophyte

(b) Halophytes (Halos= salt)

They grow in sea marshes or in saltish water. In salty condition water moves outside the cell which is not suitable for plants. To move water from outside to inside the plant develop following characters.

- Plants develop salt glands where plant store salts by taking it through active transport.
- Plants oppose salt to move outside from vacuole.
- Some salt accumulated at surface of leaf which attracts water from air

Fig. 2.4 Halophyte

(c) Mesophytes:

The plant grow in moderate water containing soil they will develop following characters.

- They have developed root system which do not grow very deep.
- They have moderate sized leaves.

Fig. 2.5 Mesophyte

(d) Xerophytes:

Plants grow in soil of low water quantity. They grow in desert or steep slopes or at high altitude. To conserve water and absorb proper amount of H_2O they develop following characters.

- They have vertically growing deep root system to absorb proper amount of water.
- They possess thick waxy cuticles over epidermis to conserve water.
- They have short sized leaves or leaves are modified into spines to reduce loss of water by reducing the number of stomata.
- Some xerophytes has special parenchyma cells in stem, where they store water, this makes the stem soft, wet and juicy called succulent organs e.g. cacti.

Fig. 2.6 Xerophyte

2.3 HOMEOSTASIS IN ANIMAL

Osmoregulation in Animals

Like plants, animals also live in aquatic and terrestrial habitat. According to their environment their cells require more critical balance of water and solutes. Water continuously leaves and enters the cells with solutes to keep the water and solute in constant quantity which are required for smooth metabolic functions.

Osmoregulation in aquatic environment

The aquatic conditions are classified on the basis of the concentration of salt present in it. The water which contains very low amount of salt called fresh water and the water contains high salt called marine water. Animal osmoregulate differently in both waters.

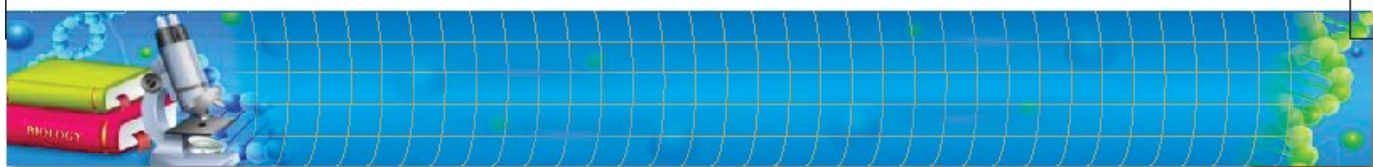
i. Osmoregulation in fresh water

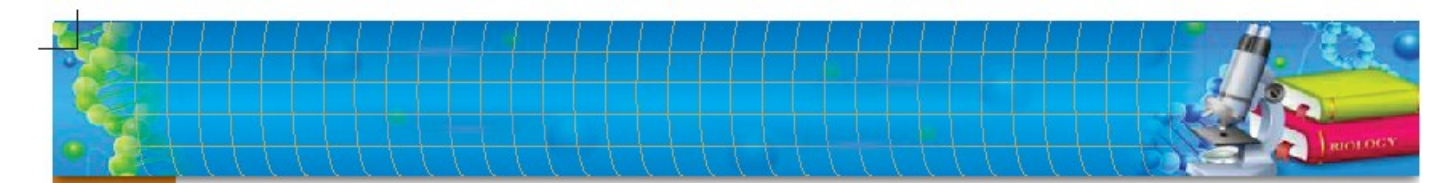
Fresh water animals have hypertonic conditions inside their body or cells so they always facing the problem of flooding of H_2O and loss of salts.

We can classify further these animals in two groups.

Unicellular	Multicellular
• Pump out excess water by contractile vacuole	• Pump out excess water by producing dilute urine.
• e.g. Amoeba, Paramecium etc.	• Loss of salt is compensated by active uptake of salt by gills and skin as well as use of salt containing food.

ii. Osmoregulation in marine animals

Usually marine animals have hypotonic conditions (low salt) inside the body but some marine animals develop hypertonic (high salt) or isotonic (same salt condition) by metabolism.

Bony fish	Cartilaginous fish	Osmoconformer
• Have low salt inside the body • Actively get sea water and have salt glands to increase the salt and desalination • Produce concentrated urine	• Have high salt by storing urea inside • Eat food which contain nitrogenous compound i.e. meat	• Have equal amount of salt. • These animals do not require any activity to adjust their internal osmotic condition. i.e. unicellular.

iii. Osmoregulation in terrestrial condition

Terrestrial conditions are harsh for living organism because the direct contact of heat to body causes loss of water which leads to dehydration, major problem for terrestrial life. Only arthropods, some molluscs reptiles, birds and mammals can survive in this habitat because:

- Their bodies are covered by exoskeleton or thick skin, which prevent loss of water.
- They conserve water by reabsorption in kidneys and rectum.
- Some of them can produce water from fats catabolism with the help of peroxysomes i.e. camel, kangaroos.
- Continuously drinking of water or using liquid food.

Excretion:

During metabolism living organisms catabolize protein and other nitrogen containing compounds which produce some toxic nitrogenous compound. These toxic compounds are mainly NH_3 or urea or uric acid generally called nitrogenous waste. If these compound retain in the body and accumulate, they can damage the cells or organs therefore they must be removed from the body. The removal of these nitrogenous metabolic waste is called excretion.

On the other hand plants metabolism is different from animal. Plants are autotrophs, initially they produce carbohydrates as primary products. Carbohydrate is catabolized to produce CO_2 and H_2O. The CO_2

reutilized in photosynthesis and H_2O is not a toxic compound. As autotrophs they synthesize variety of compounds, so the waste products of one reaction are utilized in other metabolic reactions as reactant and consumed.

Excretion in animals:

The animal cells produce their nitrogenous waste during metabolism and removed them either in tissue fluid or in blood. So the animals develop some organs to filter the tissue fluid or blood. These organs are called excretory organs.

Name of animal	Excretory organs	Excretory compound	Source
Planaria (Platyhelminthes)	Flame cells (Protonephridia), Excretory ducts	Dilute urine	Tissue fluid
Earthworm (Annelids)	Metanephridia	Dilute urine	Coelomic fluid
Cockroach (Arthropod)	Malphigian tubules	Uric acid pellets	Haemolymth
Vertebrate	Kidneys	Nh_3, Urea, Uric acid	Blood

2.4 HOMEOSTASIS IN MAN

Humans have well developed homeostasis systems. The main organs which involved in homeostasis are

(i) Skin
(ii) Lungs
(iii) Kidneys

(i) Skin:

The skin is considered as the largest organ of the body, basically functions as a protective organ as the first line of defense but it also works efficiently as a homeostatic organ by maintaining temperature, water and salt.

(ii) Lungs:

They maintain levels of O_2 and CO_2 in the blood, body fluid and cells. Maintenance of O_2 and CO_2 level, maintain rate of respiration and continuous flow of energy.

(iii) Kidneys:

Kidneys are called filters of the body fluids, they maintain internal water by removing excessive water, also maintain urea, uric acids, creatinine and other waste by excreting them through urine

2.4.1. Structure of Human Skin

Human skin consists of three layers called epidermis, dermis and hypodermis. The outer layer of skin is epidermis, made up of flat, dead cells containing keratin protein. This layer does not contain blood vessels. It is impermeable to water and prevent water loss from the body as well as work as protective layer by preventing entry to microorganisms.

Dermis is the layer present between epidermis and hypodermis, it contains many different structures i.e. nerves ending receptors to detect temperature change, pain, pressure etc. The dermis also contains sweat glands which secrete sweat on the surface to maintain temperature and also secrete urea, water and salt.

A network of arterioles are also present in the form of network, which are involved in temperature regulation. The dermis also contain hair follicle and sebaceous glands which secrete oily sebum.

Hypodermis is the inner most layer of skin containing fats which act as insulation against loss of heat. It also stores energy.

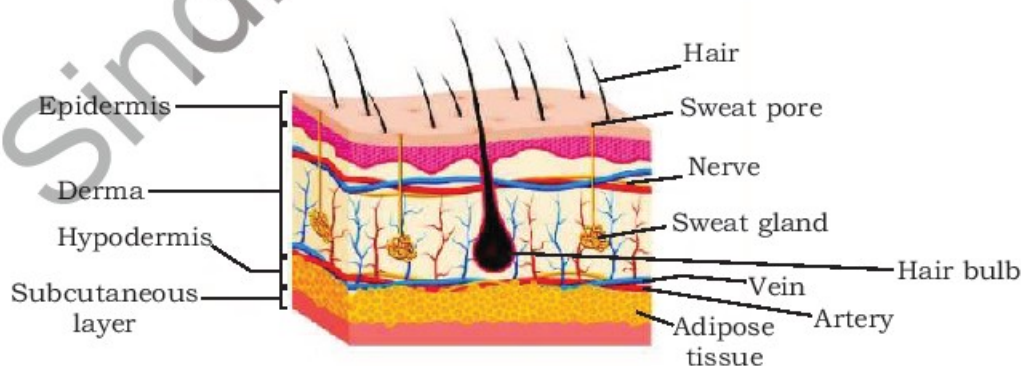



Fig. 2.7 LS of human skin

2.4.2. Role of Skin in Regulating Body Temperature

The skin is the organ which help in regulating body temperature when the receptor in skin detects change in body temperature from set point (set point of human is 37°C) i.e increase or decrease, and then Receptor send nerve impulse to the brain. It occurs by feedback mechanism to correct the temperature.

If Body Temperature Start Rise

(i) Production of sweat:

The sweat gland starts to produce and secrete sweat. The sweat accumulates at the surface of skin which evaporates with heat energy so the body feels cooling.

(ii) Laying down of hairs:

In hot condition, muscles which are attached with hair relax. It allows the hair to lie flat against surface of the skin

(iii) Vasodilation:

Arterioles found in the form of network in dermis, dilate (become wide) which increase the flow of blood, as well as it brings the blood vessels near the surface of skin which allows more heat loss. This process of vessel dilation is called vasodilation.

In cold condition when body temperature starts decreasing

(i) Erection of hairs:

The muscles contract pulling the hairs upright and trapping a layer of insulating air next to skin. Now it is not very much effective in human.

(ii) Vasocontraction:

Narrowing of blood arterioles of dermis occurs which reduces the blood flow in capillaries of skin so less heat is lost.

(iii) Decrease in sweat production:

The sweat gland stops to produce and secrete sweat, so ir prevent from energy loss.

(iv) Increase in metabolic rate:

In cold conditions the rate of metabolism in the organs increases generating more heat which is distributed around the body in the blood stream. It prevents loss through the adipose tissue in hypodermis which work as an insulation layer.

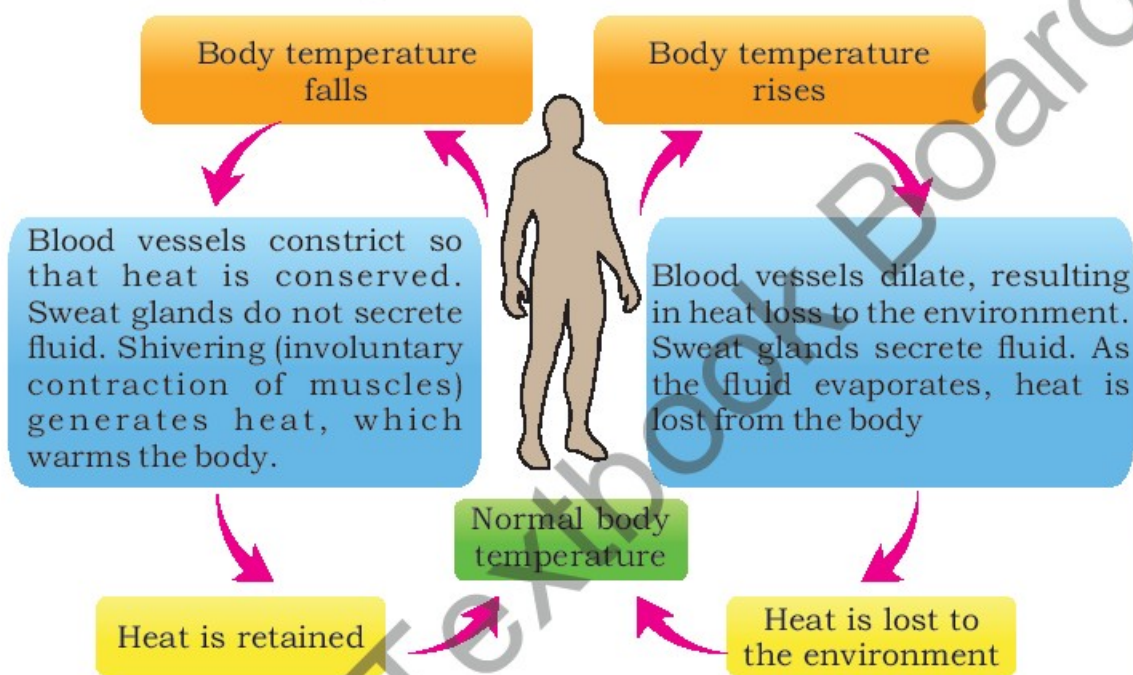



Fig. 2.8 Thermoregulation in Man

2.4.3. Role of lungs to keep the CO_2 concentration low to certain level

Tissue/cells produce a large amount of CO_2 during aerobic respiration. As blood passes through tissues via blood capillaries, this CO_2 diffuses into the blood, where it reacts with water form carbonic acid. This reaction takes place by an enzyme called carbonic anhydrase present in R.B.C. The carbonic acid dissociate into H^+ and bicarbonate $H^{-1}CO_3$ions. The level of H^+ in blood is continuously monitored by special detectors (receptor) carotid bodies and aortic bodies. Most of the bicarbonate ions diffuse out from R.B.C to blood plasma. A small amount of CO_2 is also carried and dissolved in R.B.C when the blood reaches lungs these bicarbonate ions diffuse back into RBC where again converted into carbonic acid then into CO_2. The CO_2 diffuses out of the blood capillaries and into alveoli, where from it is expelled out when breathing out.

If the CO_2 level increases in blood, pH of blood start increasing so that the receptor sends a message to the control centre which ultimately increases the breathing rate to expel out the CO_2 efficiently.

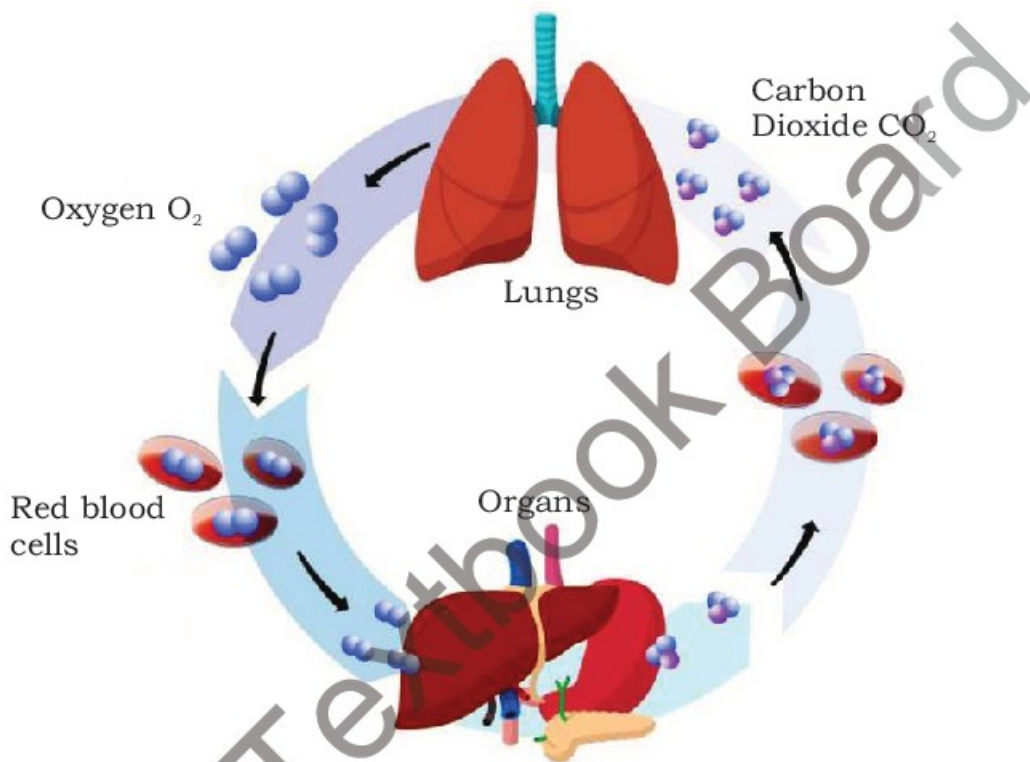



Fig. 2.9 Role of lungs in keeping low CO_2 and high O_2 level in blood

2.4.4. Role of kidney in controlling blood composition

Blood is the fluid having cells. In plasma, it contains a high amount of H_2O and some solutes like Na^+, Cl^-, Ca^{++}, K^+ etc. with nitrogenous waste. Liver continuously produces urea and NH_3 by breaking amino acid, we continuously take different solute ions in our food like Na^+, Ca^{++}, K^+ etc. the concentration of H_2O, solute and nitrogenous waste are maintained by kidney through process of filtration and reabsorption, which we will study in next topics.

2.5 URINARY SYSTEM IN MAN

The urinary system of human is consist of

- A pair of kidney

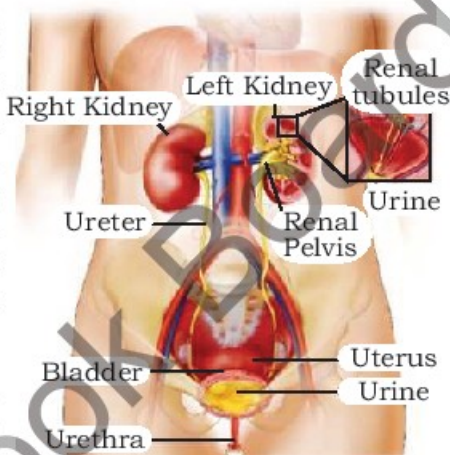
- A pair of ureters
- A urinary bladder
- A urethra

Kidneys are reddish-brown bean shaped organs, situated at the dorsal side of the abdominal cavity on either side of the vertebral column. The kidneys lie above the waistline. Each kidney has an area in the center of concave surface which faces the vertebral column; this area is called hillus. The renal artery, renal vein, nerve and ureter are connected to each kidney at the hillus.

Fig. 2.10 Urinary System

The ureter is a narrow tube which connects the kidney to the urinary bladder. Urine passes through ureter to the urinary bladder.

The urinary bladder is a thin walled muscular bag situated towards the bottom of abdominal cavity in front of the rectum which stores urine.

The urethra is a tube which comes out from the urinary bladder, runs down and opens outside the body through urinary opening. It passes urine from bladder to outside the body.

2.5.1 Structure of a Kidney

Kidney is enclosed in a membrane called peritoneum. A fluid is filled in between **peritoneum** and kidney called peritoneal fluid which reduces the friction. A longitudinal section of kidney shows three main parts: the cortex, the **medulla** and the **pelvis**.

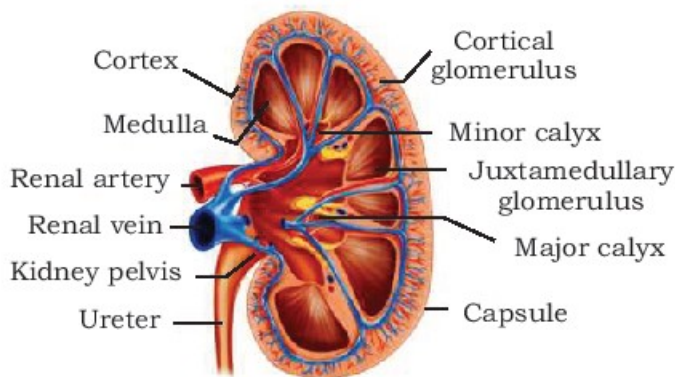



Fig. 2.11 LS of Human Kidney

Cortex is the outer dark brown portion. It is covered and protected by a fibrous capsule. The **medulla** is the inner lighter portion of the kidney. It contains the conical projection called **renal pyramids**; the human Kidneys contain 12-16 pyramids. The medulla contains nephrons. **Nephrons** are the basic functional units of the kidney. These are tiny kidney tubules where osmoregulation occurs to produce urine. The kidneys are connected to the ureter at pelvis. **Pelvis** is a funnel like space. It is the enlarged portion of ureter inside the kidney.

2.5.2 Structure of Nephron

Nephrons are the functional unit of kidney. Each kidney contains more than one million nephrons, which are microscopic urinary tubules. Each nephron consists of four main parts: The Bowmann's capsule, proximal convoluted tubule, Loop of Henle's, distal convoluted tubule. Number of nephrons open into a tube called **collecting duct**.

Nephrons are surrounded by different blood vessels that are connected to the renal artery and renal vein.

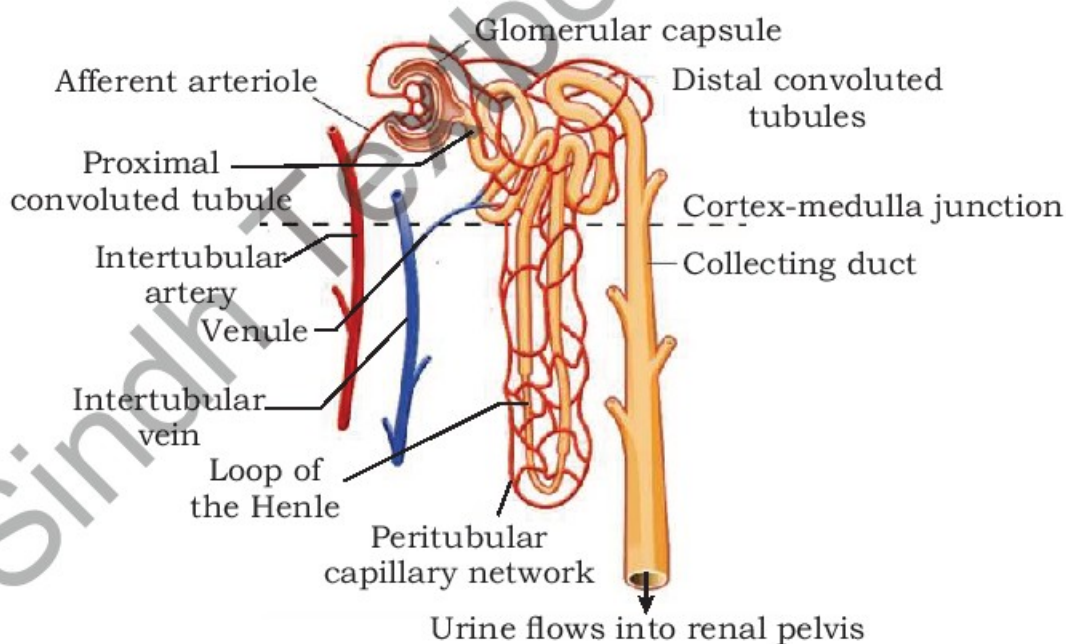



Fig. 2.12 Structure of Nephron with Blood Vessels

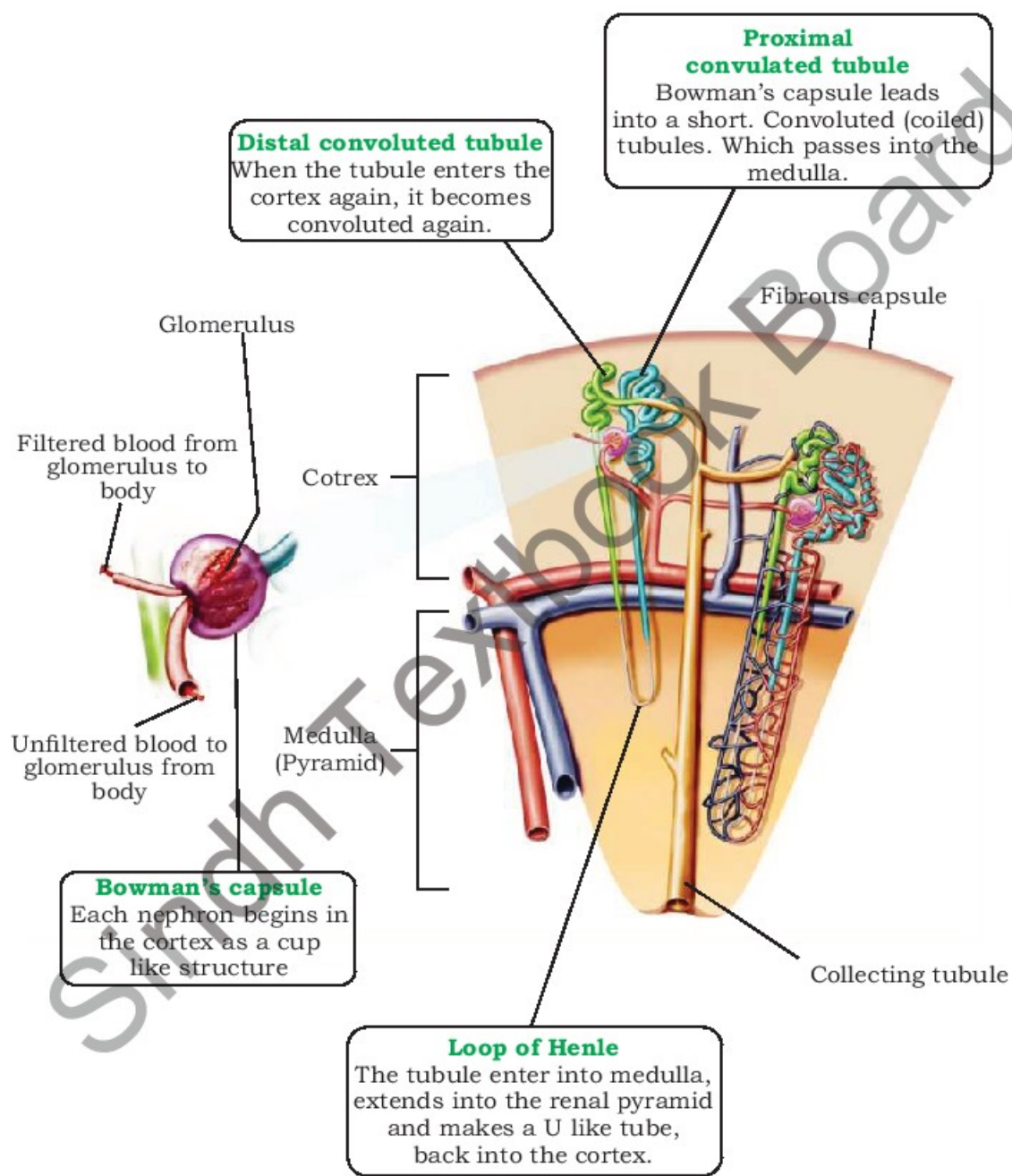



Fig. 2.13 Section of Kidney showing structure of two nephrons with blood supply

2.5.3. Function of Nephron

The renal artery when enters into kidney, it divides into millions of branches called afferent arteriole. The blood enters the kidney by renal artery goes into afferent arterioles.

Each afferent arteriole further divides into numerous blood capillaries in Bowmann's capsule are collectively called glomerulus. Bowmann's capsule with glomerulus are collectively called Malpighian body or renal corpuscle.

Blood leaving the glomerulus through efferent arteriole, enters blood capillaries surrounding the nephron.

Blood capillaries surround a loop of Henle's unite to form venule, which ultimately joins to form a branch of renal vein.

2.5.4. Role of kidney in urine formation

Urea formation

The urea is formed within the liver cells. The liver stores surplus glucose of food by converting it into glycogen and other food substances but it can not store the proteins. The excessive amino acid break and get

some energy from it. The amino group (NH_2) is removed from amino acid called deamination. This NH_2 group is converted into ammonia (NH_3) which is very poisonous, it may kill the cell when stored in high concentration. So the liver cells quickly convert NH_3 into less toxic substance **urea**. This urea is carried by blood to kidneys and excrete out in the form of urine. A small amount of urea is also excreted in sweat as well.

Urine formation

Excess mineral salt and nitrogenous waste products i.e. urea, creatinine and uric acid, which are poisonous if accumulated. These are removed from body with water and this mixture is called urine.

Urine formation takes place in Kidneys. Two main processes are involved in the formation of urine within nephron.

(i) Filtration

(ii) Reabsorption

(i) Filtration

Filtration is the process of taking out material from blood. It is of two types:

(a) Ultrafiltration

(b) Selective filtration

Fig. 2.14 Ultra Filtration in Glomerulus

(a) Ultrafiltration

Ultrafiltration occurs at Malpighian body when the blood from afferent arteriole enters into glomerulus located in Bowman's capsule. Most of the blood plasma is forced out of the glomerulus blood capillaries into Bowman's capsule without any selection. Process of non-selective filtration is called ultrafiltration.

(b) Selective filtration

Selective filtration occurs at proximal and distal convoluted tubules when blood flows into peritubular capillaries, the remaining amount of urea filter out from blood by active transport. It requires some energy

(ii) Reabsorption

In a normal adult about 120 Cm^3 of filtrate is formed in the kidney every minute. If this large amount of filtrate allowed to pass out from the body as urine, the body will dehydrate and death may occur. To prevent this huge loss of water and useful salts, when the filtrate passes through the nephron useful substances and excessive water reabsorbed into the blood stream by:

(a) Non-selective

(b) Selective reabsorption

(a) Non-selective reabsorption

Non-selective reabsorption occurs at distal and proximal convoluted tubules without any selection.

(b) Selective reabsorption

Selective reabsorption occurs at Loop of Henle's and collecting duct with the help of hormones. i.e. Antidiuretic hormone (ADH), Parathyroid hormones (PTH) and calcitonin.

Fig. 2.15 Resorption of Material in Nephron

2.5.5. Role of kidneys in osmoregulation

The water potential (capacity to loose water) of blood in the body has to be kept constant because big and sudden change in the water potential of blood can lead to serious problems e.g. if plasma becomes very much dilute water will enter the blood cells will swell and possibly burst.

On the other hand if the blood plasma becomes too concentrated, water will move out of the cell by osmosis, as a result of it the blood cells, tissues will become dehydrated and shrink. This control of water and salt content of the body is known as osmoregulation.

Kidney is not only an excretory organ, it also regulates water and salt balance in the blood. Kidneys makes sure that the concentration of blood stays more or less constant.

Sweating i.e Loss of H_2O

↓

Water potential of blood decreases

Stimulates

Hypothalamus

ADH hormone release from pituitary gland

↓

Collecting duct of nephron absorb H_2O into cell → capillaries

- Urine produce in small quantity
- Concentrated urine produce

Intake of H_2O by drinking

↓

Water potential of blood increase

Stimulates

Pituitary gland releases less ADH

↓

Collecting duct of nephron absorb less H_2O into cell → capillaries

↓

- Renin produce in high quantity
- Dilute urine produce

↓

Water potential of blood returns to normal.

Fig. 2.16 Role of Kidney in Osmoregulation

2.6 DISORDERS OF KIDNEYS

Kidney Stone

A kidney stone is a solid mass that forms from the crystals of calcium oxalate or Calcium Carbonate. Sometimes uric acid and cysteine are also present in it. These molecules separate from urine, precipitate in kidney and deposit in the form of stone. Sometimes these stones are not hard therefore they break into sand like crystals which can pass out of the body with urine without pain. The little large size stone however damages the kidney tissues, it may stuck anywhere in urinary tract and cause renal failure with pain.

Fig. 2.17 Lithotropsy machine

Treatment of Kidney Stone

If the size of stone is comparatively small we can use the technique of lithotripsy to break stone by ultrasonic waves (sound waves). The broken rudiments drain out from kidney with urine.

The large size stone cannot be broken by lithotripsy, so it is removed only by the process of renal surgery.

The large intake of water is the only measure to minimize the chances of formation of stone in kidney.

Kidney Failure

Sometimes the nephrons of kidney stop working, it is called kidney failure. It is mainly due to solute disbalance in blood and kidneys. The failure of kidneys allows urea and other waste material to accumulate in blood. The amount of H_2O is not regulated also. This disbalance of solutes causes death unless the patient is given treatment to filter out waste by machine.

(i) Kidney dialysis

Patient of kidney failure may get a kidney transplant. A person with two healthy kidneys may donate one kidney and survive with one kidney. If a donor is not available, the patient can be treated with dialysis using a dialysis machine. A dialysis machine performs the function of a kidney. It helps to clean the patient's blood from metabolic waste products and toxics.

For effective treatment the patient needs to undergo dialysis 2-3 times a week. Each session lasts about 3-5 hours depending on the patient's body size and medical condition.

Blood thinners prevent clotting

Pump

Arterial blood leaves the arm

Dialysis fluid in

Dialysis fluid carring waste products and urea is removed

Clean blood returns to a vein in the arm

Dialysis machine

Clean blood flows through bubble trap to get rid of any bubbles

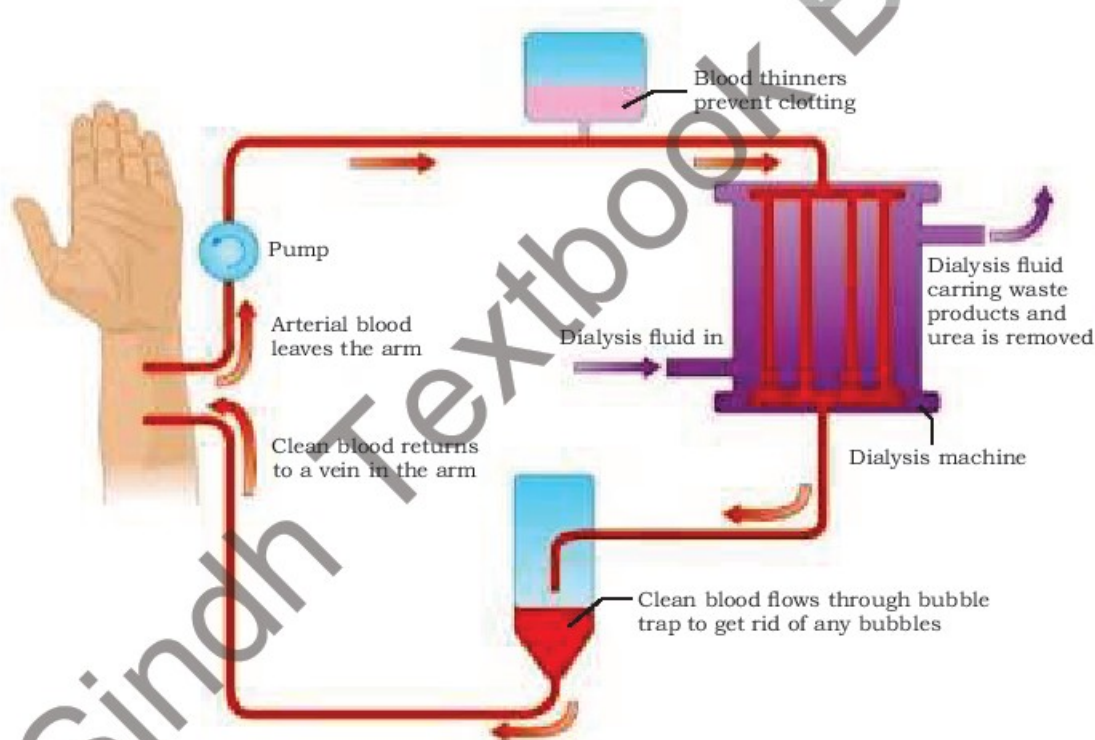
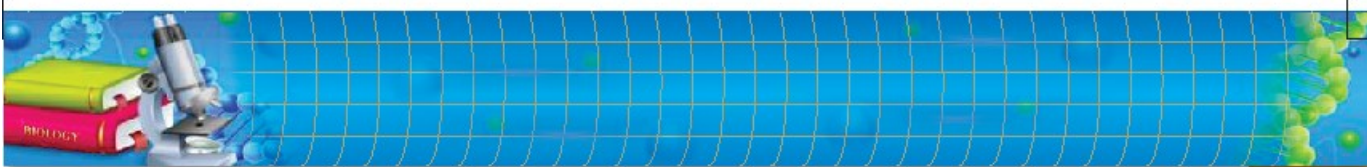



Fig. 2.18 Working of Dialysis Machine

SUMMARY

- Homeostasis is set of metabolism which maintain internal environment of an organism within suitable limits.
- Organisms maintain internal condition by feedback mechanism.
- There are three main aspects of homeostasis i.e. osmoregulation, thermoregulation and excretion.
- Osmoregulation is the maintenance of internal water and salt condition by osmosis.
- Thermoregulation is the maintenance of temperature within suitable limits where enzymes can work optimumly.
- Excretion is the process where metabolic toxic wastes, excess substances remove from body.
- Hydrophytes are the plants which grow in fresh water.
- Halophytes grow in sea marshes or in saltish water.
- Mesophytes are the plants grow in moderate water containing soil.
- Xerophytes are the plants grow in soil of low water quantity.
- The main organs involved in human homeostasis are skin, lungs and kidneys.
- Human skin is consist of three layers called epidermis, dermis and hypodermis.
- Body temperature when rise body produce sweat, hair lies flat, vasodilation.
- When body temperature decrease the erection of hairs, vasocontraction, decrease in sweat production and increase in metabolic rate occurs.
- Lungs keep the CO_2 concentration at low level.
- Kidneys maintain blood composition by maintain level of H_2O, solutes and nitrogenous waste by the process of filtration and reabsorption.
- Kidneys are situated at the dorsal side of the abdominal cavity on either side of the vertebral column.
- Nephrons are functional unit of kidney.
- Urea is formed in liver and excreted from kidneys.
- Mixture of urea, creatinine, uric acid and water called urine.
- Kidney stone is a solid mass made of calcium oxalate or carbonate crystals.
- Kidney failure patient can be treated with dialysis machine, dialysis machine performs the function of a kidney.

EXERCISE

A. MULTIPLE CHOICE QUESTIONS

Choose the correct answer:

i) The internal condition of an organism is referred as:
(a) Homeostasis (b) Internal environment
(c) Internal metabolism (d) Feedback mechanism

ii) A set of metabolism reaction which maintain internal environment is:
(a) Positive feedback (b) Negative feedback
(c) Osmoregulation (d) Homeostasis

iii) Removal of extra liquid water is:
(a) Exudation (b) Guttation
(c) Respiration (d) Transpiration

iv) Plant grow near coastal area called:
(a) Xerophyte (b) Halophyte
(c) Epiphyte (d) Hygrophyte

v) Organ of human body which is considered on the largest organ is:
(a) Skin (b) Digestive tract
(c) Liver (d) Brain

vi) The maintenance of body temperature with in suitable limit is called
(a) Homeotherm (b) Thermoregulation
(c) Osmoregulation (d) Heterotherm

vii) The kidney is enclosed in a membrane called
(a) Pericardium (b) Peritoneum
(c) Pleural membrane (d) Plumule

viii) The network of blood capillaries present in the layer of skin:
(a) Epidermis (b) Dermis
(c) Hypodermis (d) Endodermis

ix) Selective reabsorption in nephron takes place at
(a) Glomerulus (b) Malpighian body
(c) Convulated tubules (d) Loop of Henle's

x) The hormone ADH release from
(a) Pituitary gland (b) Kidneys
(c) Liver (d) Lungs

B. SHORT QUESTIONS:

i) Why homeostasis is required?
ii) Why plants remove liquid water instead of water vapours?
iii) How plant survive in saltish water?
iv) Why skin is considered as excretory organ?
v) What type of structures are present in dermis to perform different functions?
vi) Draw a neat and labelled diagram of nephron.
vii) What is kidney stone?
viii) How human skin maintains temperature in cold conditions?
ix) When dialysis is required?
x) Why filtration at Para tabular capillaries called ultra filtration?

C. EXTENSIVE RESPONSE QUESTIONS:

i) How skin works as thermoregulatory organ?
ii) Describe the urinary system of man with the help of diagram
iii) Describe the structure of nephron within the L.S of kidney.
iv) Describe the network of blood vesseles in nephron and their functions.
v) Describe different disorders of kidneys and their treatment.

Chapter 3

COORDINATION

Major Concept

In this Unit you will learn:

- Introduction
- Types of Coordination (Nervous and Chemical Coordination)
- Human Nervous System
  - ★ Components of Nervous System
  - ★ Structure and Function of Neuron
  - ★ Reflex Action and Reflex Arc
- Receptors of Man (Eyes and Ears)
- Endocrine System
  - ★ Important Endocrine Glands (Pituitary, Thyroid, Pancreas, Adrenal, Gonads)
- Nervous Disorders (Paralysis and Epilepsy)

3.1 INTRODUCTION:

The organisms have to perform various tasks in order to live. To achieve their tasks, there must by coordination and interaction among different parts or organs of the body. This results in proper activity or response.

Have you ever have touched some hot object accidentally? Can you recall what you did then suddenly? You must have removed your hand immediately from that hot object. Do you know how and why you did that? The environmental conditions are always subject to change without any warning. In order to live, the living organisms have to adjust themselves according to the changing conditions. Such adjustment would only be possible when they can detect changes, analyze them and issue commands accordingly to various organs of the body. This will make not only their survival possible but also ensure the continuity of their species.

So, coordination is defined as the process where different units of a system work together to perform a meaningful function.

Stimulus:

It refers to any factor which cause change either in internal or external environment of the organism. The changes are detected by special cells or organs termed as **receptors**. For example, eyes are photoreceptors (sensitive to light), ears are sound receptors, nose is chemoreceptor for gases and tongue is chemoreceptor for solids or liquids.

A stimulus is:
A change in the environment that can be detected by a sense organ and bring about a response

Fig. 3.1 Stimulus

Response:

It is the activity performed by some living organism after analyzing stimulus or stimuli. It is exhibited by organs like muscles, glands which are termed as **effectors**.

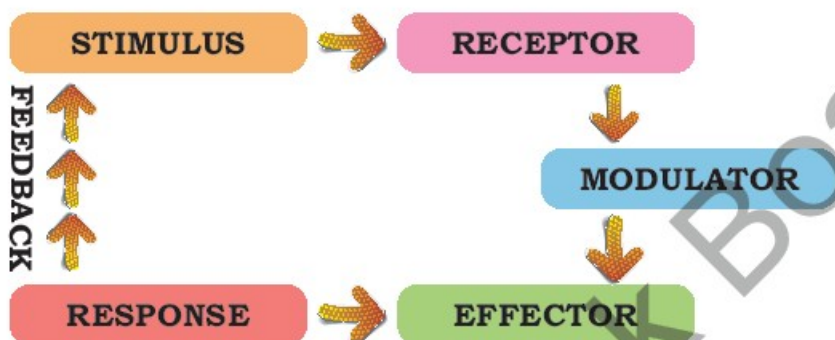



Fig. 3.2 Response activity

3.2 TYPES OF COORDINATION:

There are two types of coordination: 1) Chemical Coordination, 2) Nervous Coordination

Both are inter-related and interact with each other to develop proper response.

1) Chemical Coordination: It takes place by releasing specific, signaling molecules such as **hormones** by special cells or glands. These molecules are released to stimulate or inhibit other cells or tissues of the body. The target cells must have receptor molecules (special receiving molecules) for signaling molecules.

This kind of coordination is helpful in lower animals as well as plants because of their simple body plans and small size.

2) Nervous Coordination: It is an advance type of coordination exhibited by most of the animals, which is a consequence of specially designed cell, **Neurons**. The neurons upon stimulation generate electrochemical signals. Since the signaling is in electric form so it is very rapid.

A comparison of Nervous coordination with Chemical coordination:

NERVOUS COORDINATION	CHEMICAL COORDINATION
1) Activity of Neurons	1) Activity of special secretory cells
2) Signal type is electro-chemical	2) Signal type is purely chemical
3) Rapid in action	3) Slower in action
4) Response is shorter duration	4) Response is longer duration
5) Advance type of coordination	5) Primitive type of coordination
6) Exclusively related to animals	6) Related to all organisms
7) Involves neurotransmitters	7) Involves other signaling molecules such as hormones.

Coordination in lower organisms and plants:

Lower organisms like prokaryotes, protozoa, algae, fungi and plants have chemical coordination through signaling molecules released usually in the form of hormones to regulate their movements, growth, metabolism, reproduction, etc. For example, leaves of the "touch me not" are closed when touched. After a short while, they restore their original open position. The pressure or touch serves as stimulus while closing down of leaves is the response.

Give at least one reason why leaves of "touch me not" fold or closed when touched?

Fig. 3.3 Touch me not plant

Other responses like growth, reproduction are due to the secretion of hormones by secretory cells and carried via the transport media to their respective target organs. Another fascinating movement is the turning towards the direction of sun in "sun flower" plants. It's a bit slower movement which is believed to be caused by phytohormones called Auxins. It causes rapid cell growth in shaded regions of the plant.

Fig. 3.4 Sun flower

3.3 HUMAN NERVOUS SYSTEM

Human nervous system like other vertebrates is "centralized-type nervous system" (CNS). It is the most complicated type. Stimuli from various organs of the body are sent simultaneously its control center or central nervous system where they are integrated, analyzed and processed to develop command in the form of response. Centralized nervous system consists of two major divisions, viz. Central Nervous System (CNS) and Peripheral Nervous System (PNS).

3.3.1 Central Nervous System:

It is the major command and control center to which stimuli are reported and decisions are made and conveyed to effector organs. It consists of two main components, brain and spinal cord.

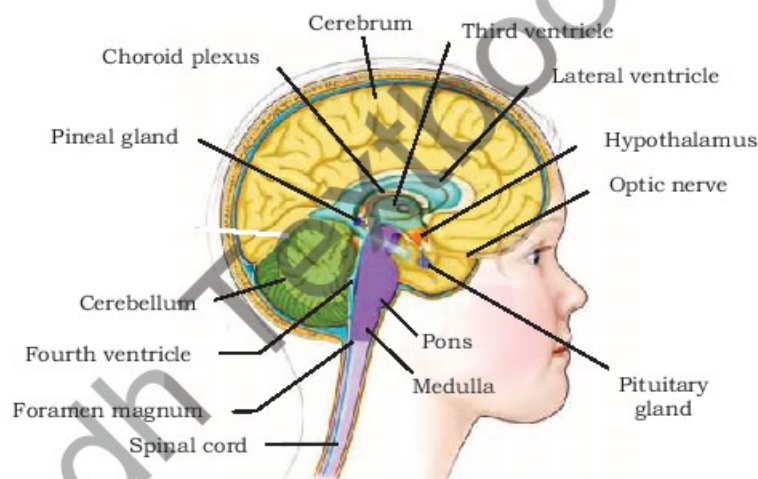
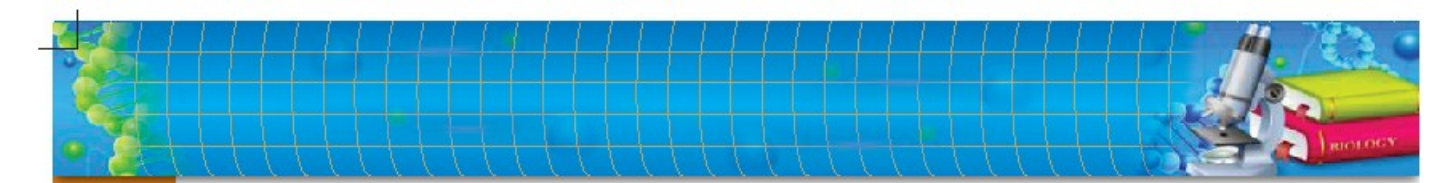



Fig. 3.5 Human brain

1. Brain: It is the major command and control center of our body. It is wrapped in three protective membranes called meninges. Inside the brain, there are empty cavities or ventricles filled with a **cerebro spinal fluid** (CSF). It also provides a cushion-like protection to the brain. Bones of the skull provide another protection to brain.

Human brain consists of following important parts: Cerebrum, hippocampus, amygdala, thalamus, hypothalamus, mid-brain, cerebellum, and medulla oblongata.

Cerebrum: It is the largest part of the brain where important decisions are made. It is considered to be the seat of intelligence, all conscious activities and memory. Its outer part, **cortex** or **gray matter** is grayish in color and consists of cell bodies of neurons while inner part **white matter** is whitish and consists of cell processes which are hair-like outgrowths. Cerebrum consists of two hemispheres, i.e. Right and left cerebral hemispheres. The right cerebral hemisphere regulates the left side of the body while the left cerebral hemisphere to the right side of the body. The cortex is associated with thoughts, plans, actions and determination. It can be divided into four sections or lobes, viz., Frontal lobe, Parietal lobe, Temporal lobe and Occipital lobe. Frontal lobe is associated with thoughts, emotions, etc. Parietal lobe is associated with different sensations like pressure, temperature, language processing, etc. The temporal lobe is involved in hearing and speech. The occipital lobe is associated with vision.

Thalamus: Thalamus lies inside in the brain just above the hypothalamus. It guides the stimuli towards appropriate part of the cortex.

Hypothalamus: Hypothalamus regulates life maintaining functions like blood pressure, body temperature, hunger, thirst, etc. It plays vital role in maintaining homeostasis of the body.

Hippocampus: It is related with long-term memory.

Amygdala: It's a deep seated small area involved in emotions (pain, pleasure, etc.)

Mid brain: In human it is relatively smaller and involved in integration of visual and olfactory (smell) stimuli. It is also collaborator of spinal cord with fore-brain.

Cerebellum: It is highly convoluted structure located on the dorsal side just below the cerebrum. It controls the precision in movement of the muscles for balance and maintains the position of the body in relation to gravity. Activities like writing, drawing, painting, dancing, crafting have become possible due to its elaborate structure in human.

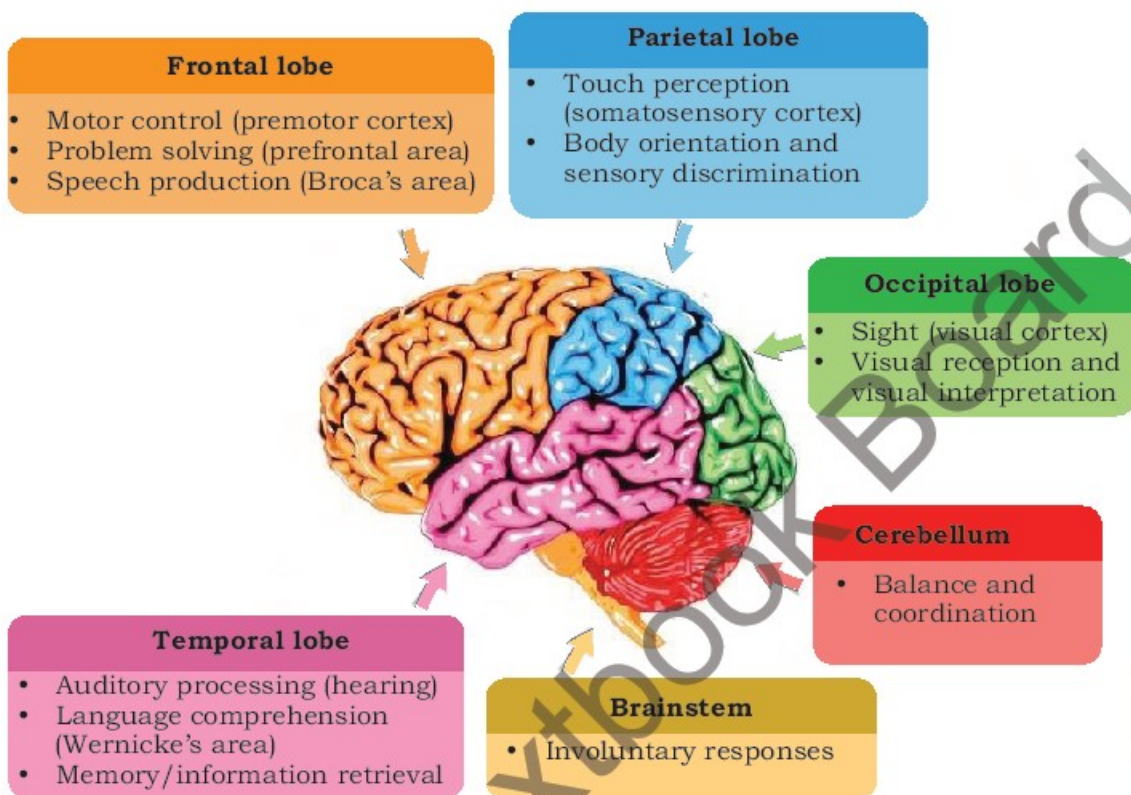



Fig. 3.6 Parts of brain

Medulla oblongata: It lies just above the spinal cord. It is the control center for automatic activities like breathing, heart-beat, blood pressure, coughing, swallowing, hiccupping, digesting food, etc. Such activities are termed as Reflexes.

Pons: It lies on the ventral side of medulla oblongata. It helps in controlling the facial muscles as well as helps in sleep and wakening.

2. SPINAL CORD: It's a butterfly shaped, thick, whitish, long tube like structure which arises from medulla oblongata and extends down through the vertebral column. Unlike brain, in cross section, its outer portion is whitish called **white matter** while inner is grayish or **gray matter**. Like brain, it is also wrapped in meninges and bathed in cerebrospinal fluid. It acts as a mini control center for few reflexes. It also

acts as express way for flow of information from brain to the different parts of the body and vice versa.

Peripheral nervous system:

It consists of cables which arise from the central nervous system and connect it to different organs of the body. Each cable is termed as a **Nerve**. Each nerve consists of bundles of axons of both sensory and motor neurons. The PNS consists of somatic nervous system and autonomic nervous systems. The somatic nervous system is associated with skeletal muscles and glands while the autonomic nervous system is associated with involuntary functions like digestion, breathing, etc. These functions are vital for maintaining life processes.

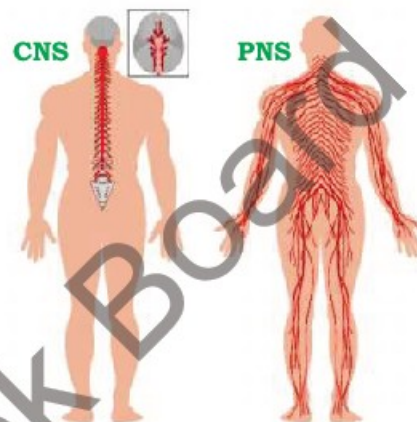



Fig. 3.7 Nervous system

3.3.2 Neuron:

The cells of the nervous system are termed as neurons. Each neuron is specialized to generate and conduct neuronal signal or **nerve impulse**. Typically, a neuron consists of a cell body or **soma** and **cell processes**. Cell body or soma comprised of plasma membrane, cytoplasm and nucleus. The cell processes are hair-like projections given out from soma. They are of two types, dendrites and axon.

Dendrites receive stimulus while axon transmits the command either to some other neuron or some **effector cells**. Like an electric cable, cell processes usually have insulated coverings, termed as **myelin sheath** to ensure the uninterrupted transmission of nerve impulse.

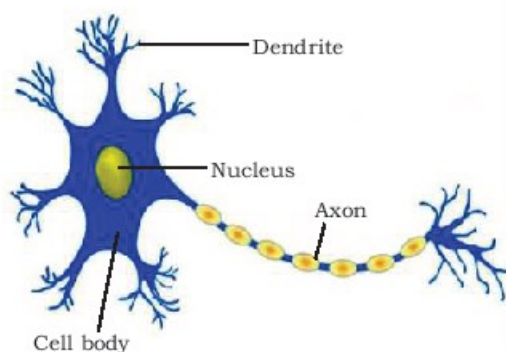



Fig. 3.8 Neuron

3.3.3 Reflex action:

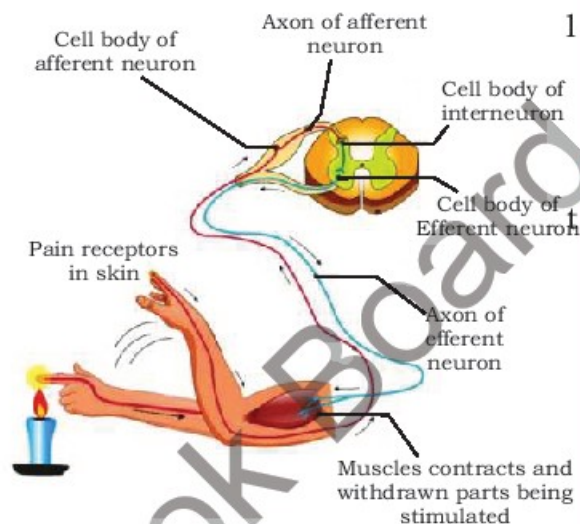
You know that activities ike blinking of eyes, hand with-drawl, knee-jerk, sneezing, hiccup, cough, etc are automatic. They are not learnt during the life ime. Such automatic, pre-programmed responses regulated by CNS are termed as reflex actions. Some of them are directly regulated by brain while others by spinal cord. The shortest path of a reflex action, such as knee-jerk nvolves two neurons, a sensory neuron and a motor neuron. The pathway of a reflex action is termed as reflex arc. In complicated reflexes, the reflex arc may involve one or numerous inter-neurons in between sensory and motor neuron.

Fig. 3.9 Reflex action

EXPERIMENT: Contraction of shin muscle (leg muscle) of Frog using battery.

Observation: Muscles contract when provided signal through neurons by nervous system. In this experiment, we observe that a shin muscle removed from dissected frog is placed in methylene blue solution in a petri dish. When artificially stimulated by power supplied i.e. 12 volts D.C. battery, it contracts.

Apparatus: Dissecting box, Frog, dissecting tray, petri-dish, 12 volt D.C. charged battery, wires.

Procedure: Dissect out a pithed frog with the help of a teacher to expose its shin muscles as shown in diagram. Remove the shin muscle with sciatic nerve carefully and place in stretched condition in petri-dish. Connect the battery with wires and then touch the shin muscle at its

beginning and end with wires. Now observe the muscle contraction. Repeat the experiment for three times.

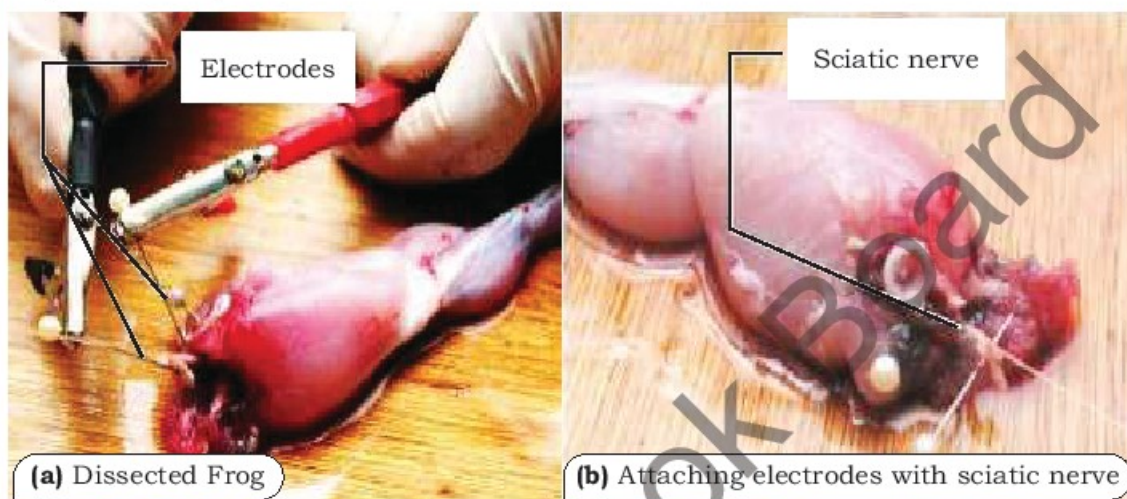



Fig. 3.10 Hind limb of frog showing sciatic nerve after dissection

3.4 RECEPTORS OF THE HUMAN BODY

Human body can detect number of stimuli like light, sound, gravity, damage to the tissues, etc, through its various receptors. We will discuss here only photoreceptor and sound receptors, i.e., eyes and ear, respectively.

Eye:

It is the organ of sight. It works on the principle of a simple camera which collects light reflected from any object in front and diverts it to a layer of sensory cells or **retina**. The light captured by retina is converted into nerve impulses and reported to the brain. Each eye lies in a bony socket for protection. A tough outer coat, **sclera** (white part of eye) covers each eye. In front, the sclera becomes transparent termed as **cornea**. Behind it, lies a small chamber, **aqueous humor** filled with watery fluid. At its back lies coloured part or **iris** with a central hole, called **pupil**. The pupil appears blackish. Immediately behind the iris is a crystalline convex **lens** suspended by a ring of circular muscles known as **ciliary body**. The

contraction of ciliary muscles causes changes in the shape of the lens to adjust focus. Behind the lens, there is a main cavity of eye ball filled with a clear gel, **vitreous humor**. The innermost layer of eye is retina on which the image is formed by cornea and lens. It has sensory cells, **rods and cones** which upon stimulation convert light signals into nerve impulses and report them to the brain.

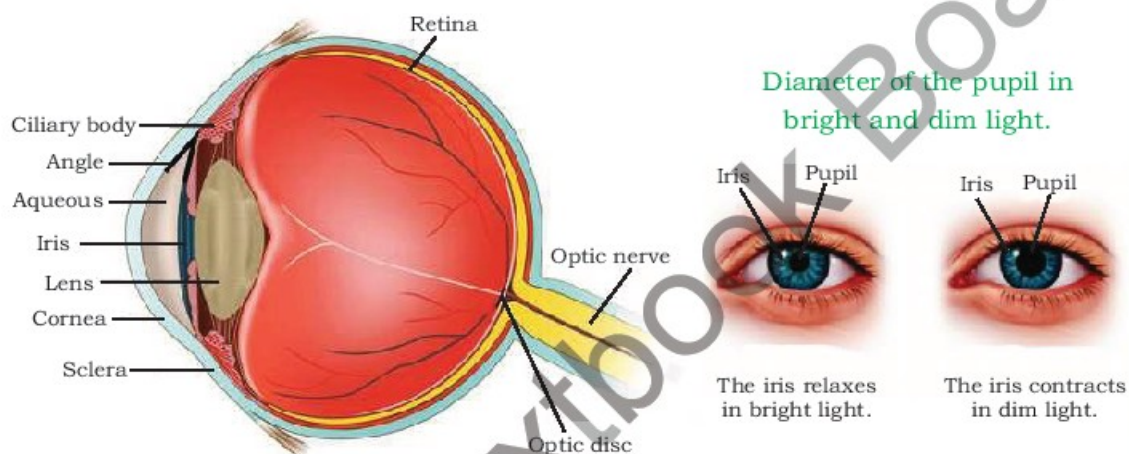



Fig. 3.11 Human eye

Pupil reflex:

The pupil adjusts itself depending upon the intensity of light. In case of bright light, it protects the retina by constricting itself so less amount of light falls on retina. Vice versa, in dim light condition, the pupil dilates to allow more light to fall on retina.

Accommodation:

It is an automatic process of altering focus to get sharper image of the near objects. To do this, the ciliary muscles contract allowing the elastic lens to become thicker and more convex. With age, the lens loses its elasticity and as a result, accommodation becomes increasingly difficult.

Role of vitamin A with vision:

Vitamin A or retinal is required for proper vision and needed for

sensory cells of retina. It also helps the cornea to be well lubricated. Deficiency of vitamin A could lead to corneal ulcers and blindness.

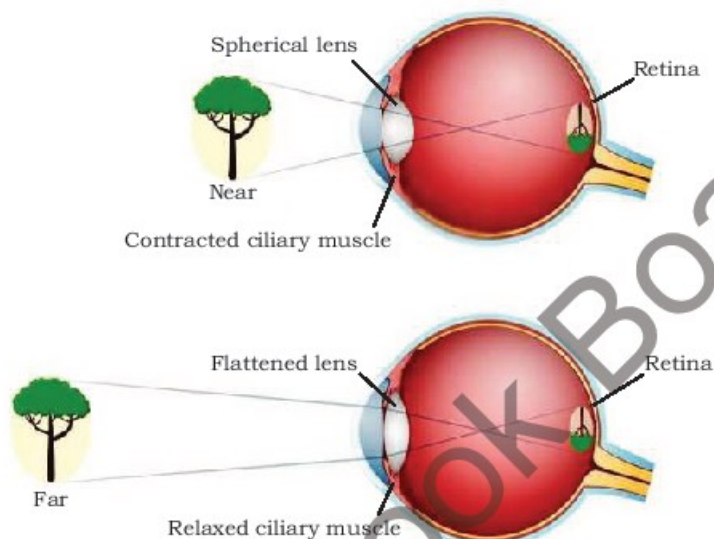



Fig. 3.12 Mechanism of accommodation

Short-sightedness and long-sightedness:

Short-sightedness **(myopia)** refers to the difficulty in focusing distant object while the near objects are focused normally. On the other hand long- sightedness **(Hyperopia)** is the difficulty in focusing closer objects while distant vision is clear. Both can be diagnosed and corrected by using appropriate glasses or contact lenses.

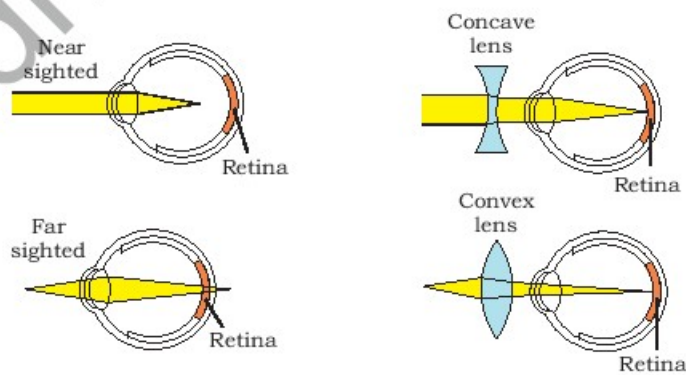



Fig. 3.13 Short sightness and long sightness

Colour blindness:

It's a deficiency of vision in which one cannot distinguish certain colours such as blue and yellow or red and green. It is due to the defect in cones of retina. Though, the vision may be normal in a colour blind person, yet the most common problem is driving because of their inability to distinguish red and green traffic lights.

Fig. 3.14 Colour blindness

Contribution of Ibn-al-Haitham and Ali-Ibn-Isa about the strucuture of eye and treatment of ophthalmic diseases:

Ibn-al-Haitham:

He was a great Muslim mathematician, philosopher, astronomer and physicist of 11^{th} century. He was considered as **"father of modern optics"** due to his great contribution in principles of optics and visual perception. He was the first person to consider vision as a result of bouncing back of light from an object and then enters our eyes. His most important book on optics was **"Kitab-ul-manazir"**.

Fig. 3.15 Ibn-al-Haitham

Ali Ibn-Isa:

He was one of the most important Muslim ophthalmologists of medieval times. In his famous book **"Memorandum of the oculists"** on ophthalmology, he described more than hundred different eye diseases and their treatment.

Ear:

Ear is an organ of hearing and balance. It consists of three parts: 1) outer ear, 2) middle ear and 3) inner ear. The outer ear consists of pinna, ear canal and tympanic membrane or ear drum. The pinna composed of folds of skin and cartilage. The **pinna** leads into the ear canal which is

closed at the inner end by tympanic membrane. Ear canal has hair and produces wax to trap dust and small foreign bodies. The outer ear collects and transmits sound waves.

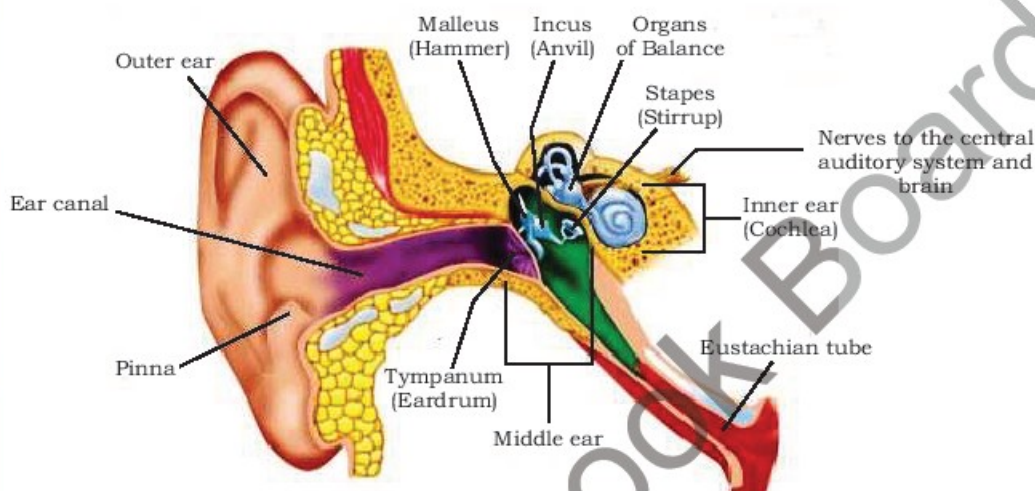



Fig. 3.16 Human ear

The middle ear consists of a small cavity containing three small moveable bones **(malleus, incus and stapes)**. The middle ear is connected to inner nasal cavity through a small tube, the **Eustachian tube**. The middle ear receives sound waves from air outside and transmits it into the fluid in the inner ear.

The inner ear consists of a front membranous **cochlea** and a rear, three **semicircular canals** deep inside the skull bones. The cochlea is associated with hearing while semicircular canals are associated with balance. Both cochlea and semicircular canals are fluid filled and contain sensory hair cells. These cells transform sound waves into nerve impulse.

Role of ear in balance:

Semi circular canals are sensitive to gravity, position and movements of head. Any of such changes are detected and reported to the brain through nerve fibers. The three semicircular canals are inter connected and lie right angle to each other. They are connected to a

swollen part, the **vestibule**. Semicircular canals and vestibule are involved in maintaining balance of the body in relation to gravity.

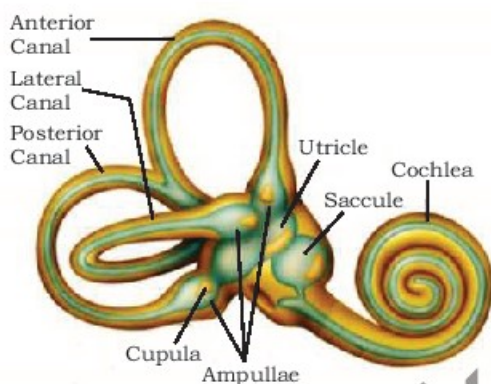



Fig. 3.17 Inner ear

Light and Sound in a thunderstorm:

In a thunderstorm, the lighting and its acoustic effect on ground appear with interval. Since the light travels much faster than sound, the lighting appears first and the sound of thunder is heard after a short while.

Fig. 3.18 Thunderstrome

3.5 ENDOCRINE SYSTEM:

It is an important means of chemical coordination. In animals, it is a system of ductless glands which secrete hormones directly into the blood. It carries hormones to their target tissues or organs. The hormones usually required in small quantity. They act like chemical signals or chemical messengers for target organs either stimulating or inhibiting their function.

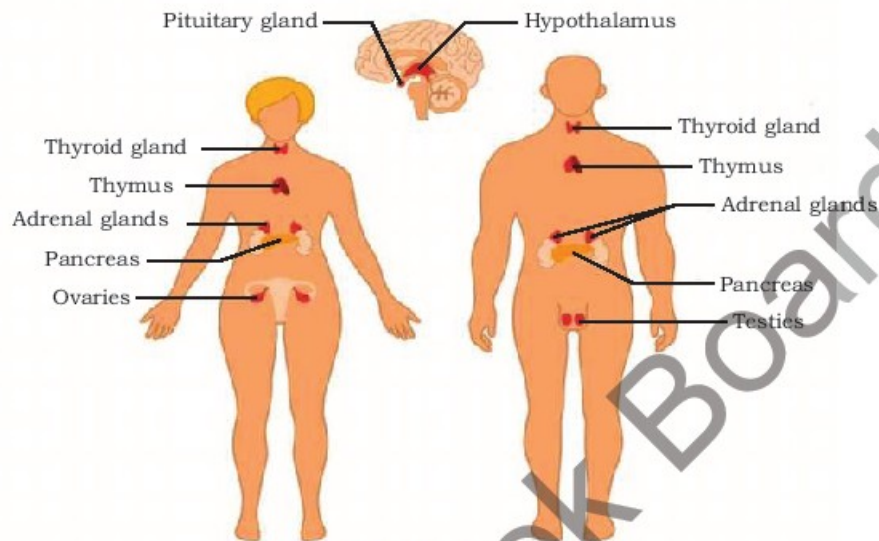



Fig. 3.19 Endocrine system

Following are important endocrine glands in human body, Pituitary gland, Thyroid gland, Pancreas, Adrenal gland and Gonads. They are located in different locations in our body.

1) Pituitary gland:

It is located in brain and considered to be very important. It secretes number of hormones which influence upon other endocrine glands also besides other organs. Pituitary gland consists of two lobes in human, an anterior lobe or anterior pituitary gland and a posterior lobe or posterior pituitary gland.

Anterior pituitary gland:

It has number of hormone secreting cells. Its important hormones and their effect with target organs are summarized in the table:

Hormones	Target organ	Important effects
Follicle Stimulating Hormone (FSH)	Gonads (Testes and ovaries)	Stimulate gonads to develop gametes

Luteinizing Hormone (LH)	Gonads	Development and release of gametes.
Thyroid Stimulating Hormone (TSH)	Thyroid gland	Stimulate thyroid gland
Somatotropin (Growth Hormone=GH)	Bones, Cartilages, muscles, etc	Growth in children and normal body structure and metabolism in adults
Adenocorticotropin Hormone (ACTH)	Adrenal cortex	Stimulates adrenal cortex
Melanocyte Stimulating Hormone (MSH)	Skin	Stimulates pigmentation (melanin) in skin

Some important hormones of Anterior Pituitary gland, their target organs and important effects

Posterior Pituitary gland:

It is actually stores and releases some hormones of hypothalamus. Few neurons of hypothalamus store and secrete their hormones from posterior pituitary gland. Examples of such hormones are **antidiuretic Hormone (ADH)** and **oxytocin**. ADH maintains the blood pressure, blood volume and tissue water. Oxytocin stimulates greater contraction of smooth muscles as well as social behavior.

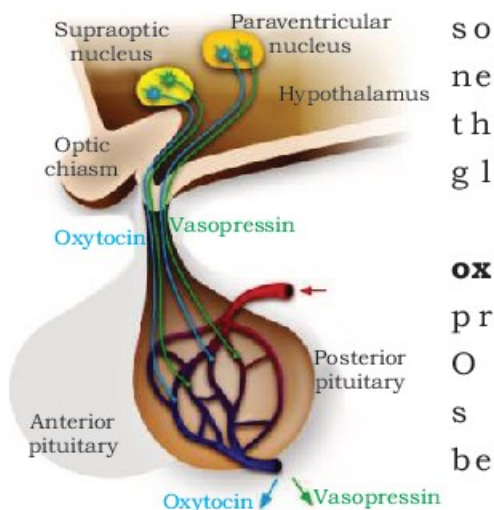



Fig. 12.20 Posterior Pituitary gland

Thyroid Gland:

It's a butterfly shaped gland located on trachea in the base of neck. It secretes **thyroxine** and **calcitonin**. Thyroxine has iodine as its important constituent. It regulates the rate of the metabolic activities of cells. It regulates the physical growth and mental development in children. In case of its deficiency, physical and mental retardation occur in children. If the intake of iodine in diet is low in adult, the thyroid gradually enlarges in size. This abnormal condtion is termed as **"goiter"**. Calcitonin released in response to high level of calcium in blood lowers the blood calcium.

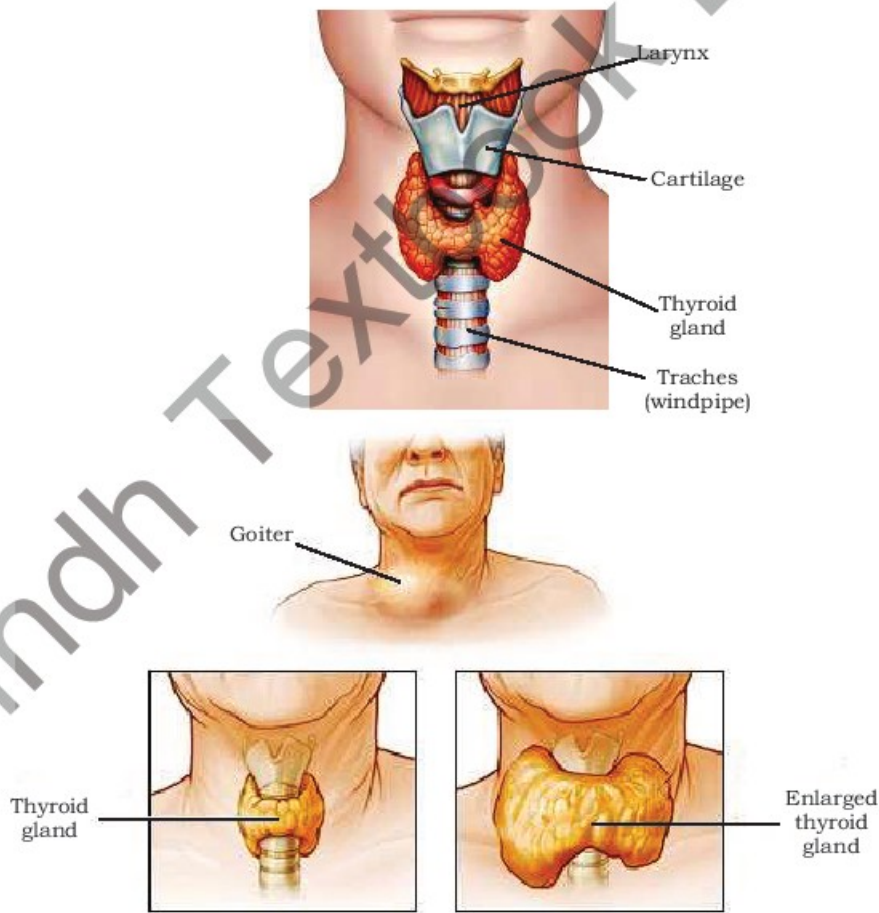



Fig. 3.21 Thyroid gland

Pancreas:

Pancreas is about 6 inches long, leaf-like in structure located in the abdominal cavity in between stomach and small intestine. It is both exocrine as well as endocrine gland in nature. The endocrine part consists of patches of cells called "Islets of Langerhan's". It is involved in regulating glucose metabolism. In response to high level of glucose, it secretes **Insulin** which helps in decreasing the blood glucose levels. On the other hand, low level of blood glucose, it secretes **glucagon** which increases the glucose level up to normal. The regulation of blood glucose through insulin and glucagon is a type of negative feed-back in which opposite effect is observed in relation to stimulus.

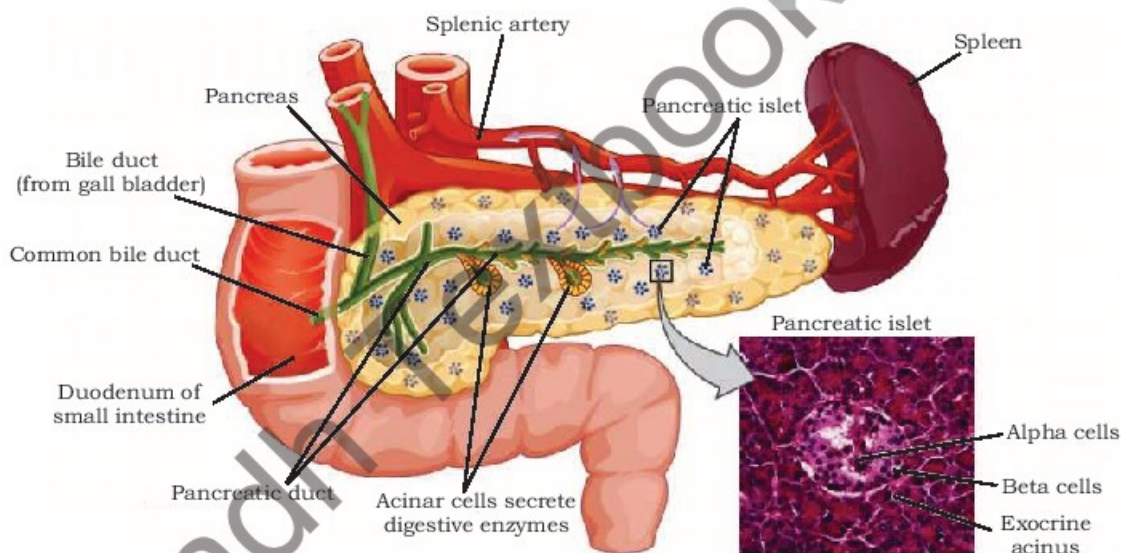



Fig. 12.22 Pancreas

Diabetes mellitus:

It's a disorder in which pancreas produces insufficient or no insulin. As a result, the level of glucose in blood becomes very high. The excess amount of glucose is excreted in urine so the frequency of passing urine increases many times. Moreover, the patient feels very thirsty and hungry. In the absence of using or storing glucose by the cells, the patient losses weight and get tired.

WAYS TO MANAGE DIABETES MELLITUS

- **Balanced Diet**
- **Exercise**
- **Medication**
- **Blood Glucose Monitoring**

Dietary Management of Diabetes

- Dietary Management and appropriate amount of physical activity play important roles in diabetic control.
- Balanced diet with a variety of foods.
- "3 Low, 1 High" principle, i.e low fat, low sodium (or salt), low sugars and high fibre.
- Reduce intake of saturated fat, trans fat and sodium can lower the risk of developing heart diseases and hypertension.
- Controlling intake of energy for the purpose of weight reduction or maintenance.

Fig. 3.23 Dietary management of diabetes

In case of low blood insulin, it can be administered through injecting insulin derived from animals. Some patients may show allergic reactions to this animal-insulin. It has been overcome by using pure human insulin made by genetically altered bacteria.

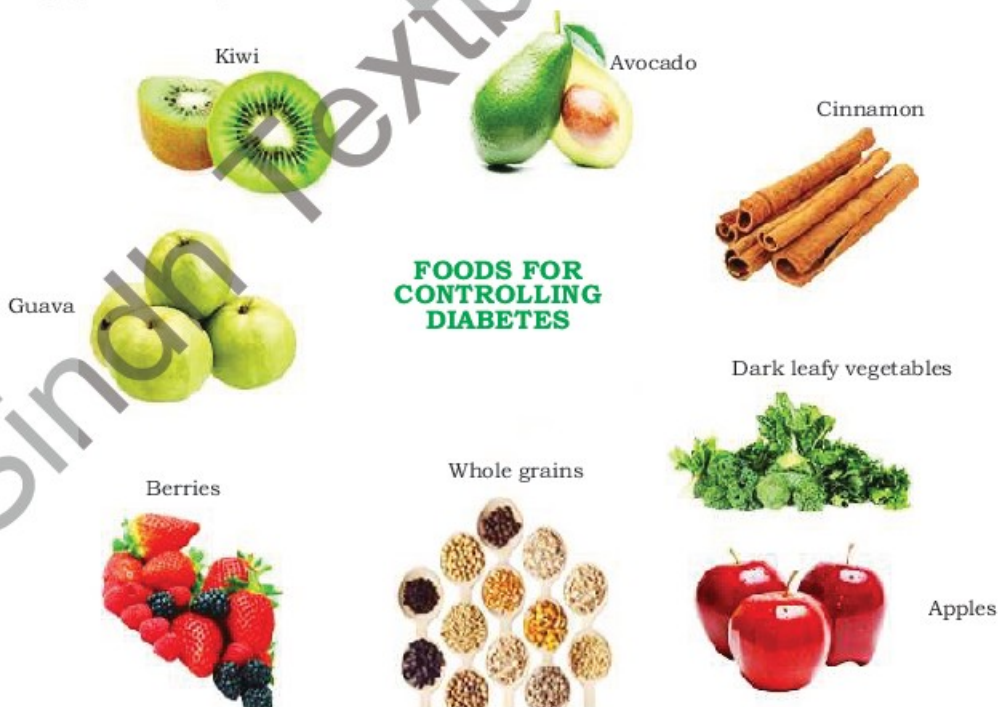



Fig. 3.24 Food for controlling diabetes

Mg/DL	Fasting	After Eating	2-3 hours After Eating
Normal	80-100	170-200	120-140
Impaired Glucose	101-125	190-230	140-160
Diabetic	126+	220-300	200+

Fig. 12.25 Blood glucose chart

ACTIVITY

Write a paper on the changes in body while performing an exercise like running a 100 meter sprint race.

Adrenal gland:

Adrenal gland is located on the top of each kidney. It is triangular shape and consists of two glands; the outer part is called **Adrenal Cortex** while the inner one is **Adrenal Medulla**. Adrenal Cortex secretes number of **steroid** (lipid) hormones necessary for regulation of body metabolism, maintenance of water and salts. **Cortisol** is one of the important hormones secreted by adrenal cortex in response to illness or inflammation of any tissue. It stimulates glucose production. Adrenal medulla responds to emergency conditions to produce so called "fight or flight response". It secretes **adrenaline** or **emergency hormone** resulting in an increase in blood glucose level by breaking down of glycogen. As a result, the body responds to the emergency situation quickly. It dilates the

blood vessels of muscles, heart and brain and constricts those of kidneys and skin so that more blood is supplied to the muscles, heart and brain.

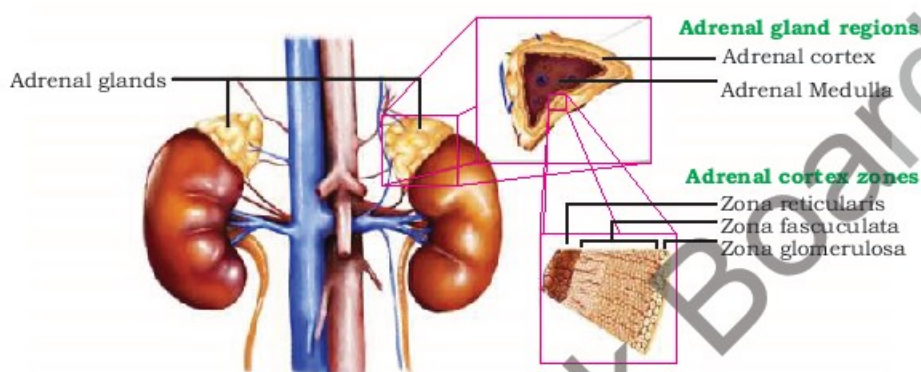



Fig. 3.26 Adrenal glands

Gonads:

Gonads are the reproductive organs, viz., testes in male while ovaries in female. They are involved in gametes formation and hormones secretion.

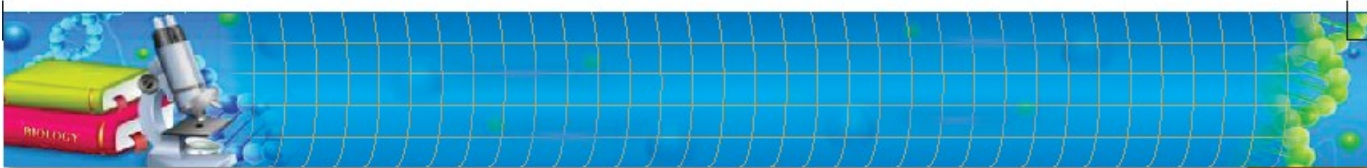
Testis:

Each testis is oval shaped structure located in a pouch of skin, **scrotum**. It secretes hormone known as **testosterone**, a type of androgen hormone. Testosterone is responsible for the development of secondary characteristics in boys like appearance of moustache and beard, deepening of voice, etc.

Ovaries:

Each ovary is about the size of a grape located in the lower abdominal cavity on either side of uterus. Ovary secretes **estrogen** and **progesterone** hormones. Estrogen is responsible for the development of secondary characteristics in girls like development of breasts, sharpening of voice, etc. Progesterone maintains and prepares uterus for pregnancy.

Feed back control mechanism of hormonal secretion:

Hormone secretion is regulated through feed-back control so that they are secreted whenever required. There are two types of feed-back systems working in the body, negative and positive feed-back controls.

Negative feed-back control:

It refers to the opposite effect in relation to the stimulus. For example, if there is an increase in blood glucose level (effect), the pancreas would secrete insulin (response) which will bring down the blood glucose to its set point.

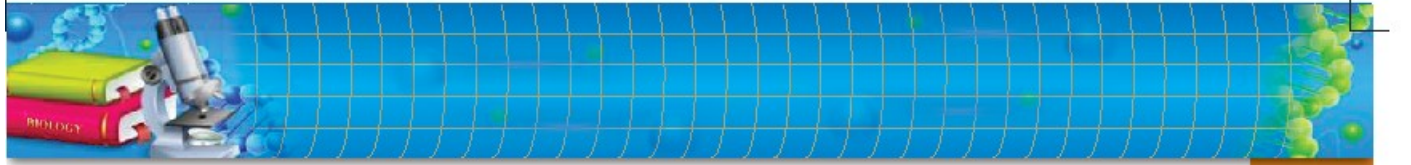
Positive feed back control:

It refers to enhancement of the effect in relation to stimulus. For example, when an infant sucks the nipple of his mother's breast, she secretes hormone to secrete milk. Further continuous sucking increases the hormonal secretion several folds.

3.6 DISORDERS OF THE NERVOUS SYSTEM:

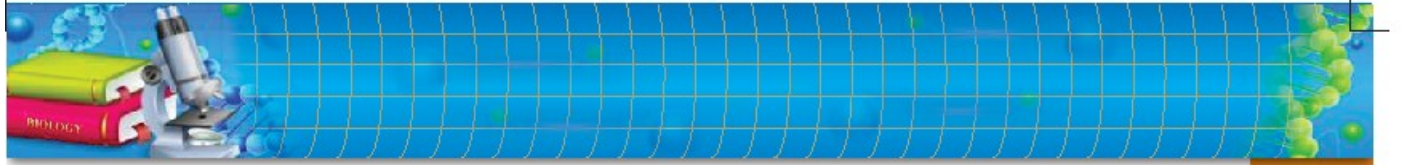
Like any other system of the body, nervous system could suffer from disorders. Depending upon the nature of disorders, they could be of two common types: Vascular (e.g. paralysis) and Functional (e.g., epilepsy).

Paralysis:

It is characterized by partial or complete loss of controlled movement caused by the inability to contract one or more muscles. It may be accompanied by loss of sensation. The most common cause is either bleeding (hemorrhage) or blood clot in the specific part of brain. However, it could be a result of injury to brain, spinal cord or nerves. It can be treated if diagnosed the exact cause. Physiotherapy of the affected muscles is required otherwise muscles may degenerate.

Epilepsy:

It is a brain disorder in which there is temporary alteration in one or more function or recurrent seizures. It is due to the abnormal electrical activity in brain. Stimulus like sudden flash light on eyes is also associated cause of the epilepsy. As a result, the victim may become unconscious with stiffness of the body and then twitches or jerks uncontrollably. The frequency of seizures can be reduced by using proper medication.

SUMMARY

- The changes or stimuli are detected by special cells or organs termed as RECEPTORS.
- The activity or response performed after analyzing stimulus is exhibited by organs like muscles, glands which are termed as effectors.
- There are two types of coordination:
  1) Chemical Coordination, 2) Nervous Coordination
- The neurons upon stimulation generate electrochemical signal.
- Lower organisms and plants have chemical coordination through signaling molecules.
- Human nervous system like other vertebrates is "centralized-type nervous system"
- Brain is the major command and control center of our body.
- Human brain consists of following important parts: Cerebrum, cerebellum, thalamus, hypothalamus and medulla oblongata.
- Spinal cord is a butterfly-shaped, thick, whitish, long tube like structure which arises from medulla oblongata and extends down through the vertebral column.
- Peripheral Nervous System consists of cables or Nerves which arise from the central nervous system and connect it to different organs of the body.
- The cells of the nervous system are termed as neurons.
- Each neuron is specialized to generate and conduct neuronal signal or nerve impulse.
- The pathway of a reflex action is termed as reflex arc.
- Human body can detect number of stimuli like light, sound, gravity, damage to the tissues, etc, through its various receptors.
- Accommodation is an automatic process of altering focus to get sharper image of the near objects.
- Vitamin A or retinal is required for proper vision.
- Short-sightedness (myopia) refers to the difficulty in focusing distant object while the near objects are focused normally. On the other hand long- sightedness (Hyperopia) is the difficulty in focusing closer objects.

- Colour blindness is a deficiency of vision in which one cannot distinguish certain colors such as blue and yellow or red and green.
- Ear is an organ of hearing and balance.
- Endocrine system consists of ductless glands which secrete hormones directly into the blood.
- Pituitary gland located in brain secretes number of hormones which influence upon other endocrine glands also besides other organs.
- Thyroid gland, a butterfly shaped gland located on trachea in the base of neck secretes thyroxine and calcitonin.
- Pancreas consists of patches of cells called "Islet's of Langerhans" which are involved in regulating glucose metabolism through their hormones insulin and glucagon.
- Diabetes mellitus is a disorder in which pancreas produces insufficient or no insulin.
- Testes secrete testosterone which is responsible for the development of secondary characteristics in boys.
- Estrogen is responsible for the development of secondary characteristics in girls, etc. Progesterone maintains and prepares uterus for pregnancy.
- Hormone secretion is regulated through feed-back control so that they are secreted whenever required.
- Paralysis is partial or complete loss of controlled movement caused by the inability to contract one or more muscles.
- Epilepsy is a brain disorder in which there is temporary alteration in one or more function or recurrent seizures.

EXERCISE

A. MULTIPLE CHOICE QUESTIONS

Choose the correct answer:

i) The activity in relation to changes in environment is:
(a) Stimulus (b) Response
(c) Both a & b (d) None of these

ii) Stimulus is detected by:
(a) Receptor (b) Effector
(c) Nerve (d) All of these

iii) The type of coordination through electrochemical signals is:
(a) Nervous (b) Chemical
(c) Mechanical (d) All of these

iv) The chemicals released from one cell and carried to signal some distant cell through blood are:
(a) Neurotransmitters (b) Enzymes
© Hormones (d) all of these

v) The type of coordination exhibited by Plants:
(a) Nervous coordination (b) Chemical coordination
(c) Mechanical coordination (d) Both a & b

vi) The part of brain involved in reasoning is:
(a) Fore brain (b) Cerebrum
(c) Cortex (d) Frontal lobe

vii) The part of brain involved in balance and precision in movements is:
(a) Cerebrum (b) Cerebellum
(c) Thalamus (d) Medulla oblongata

viii) Vital functions for survival of animals are regulated by:
(a) CNS (b) PNS
(c) somatic sub-division (d) Autonomic sub-division

ix) The shortest path of reflex action consists of:
(a) 1 neuron (b) 2 neurons
(c) 3 neurons (d) many neurons

x) The type of lens in our eye is:
(a) Convex (b) concave
(c) Both a & b (d) None of these

xi) The automatic process of altering focus to get sharper image of near object is:
(a) Vision (b) Accommodation
(c) Focus (d) All of these

xii) The vitamin necessary for proper vision is:
(a) Vitamin A (b) Vitamin B
(c) Vitamin C (d) Vitamin D

xiii) A colour blind person cannot see:
(a) Anything (b) Red
(c) White (d) Black

xiv) The book "Kitab-ul-manazir" was written by:
(a) Jabir bin Hayan (b) Ibn-al-Haitham
(c) Ali Ibn-Isa (d) Bu-Ali Sina

xv) Sensory hair-cells are present in:
(a) Retina (b) Cochlea
(c) Skin (d) Nose

xvi) The gonads are the target organ for:
(a) FSH (b) LH
(c) Both a & b (d) None of these

B. SHORT QUESTIONS:

i) What do you mean by feedback system?
ii) Why the nervous coordination is faster than chemical coordination?
iii) Which of the two coordination types is better and why?
iv) How reflex action works by a reflex-arc?
v) Why driving license is not issued to a color blind person?
vi) Why thyroid gland swell up and give the name of the disease?
vii) What is the role of Islet's of Langerhans cells?
viii) What is "emergency hormone" and why it is named so?
ix) What are the possible reasons of paralysis?
x) What is Epilepsy?
xi) Differentiate between Chemical and Nervous Coordination.

C. EXTENSIVE RESPONSE QUESTIONS:

i) Discuss the detailed structure of human brain?
ii) Write a note on human eye or ear.
iii) Why does the intelligence level of persons differ from each other, even though the components of brain are same?
iv) What is endocrine system? Discuss the gland involved in regulation of blood glucose and how?
v) What is diabetes mellitus? Explain some ways of its management.

Chapter 4

SUPPORT AND MOVEMENT

Major Concept

In this Unit you will learn:

- Introduction
- Concept of Movement
- Concept of Support and its Requirement
- Types of Skeletons
- Human Skeleton (Axial Skeleton and Appendicular Skeleton)
- Ball-n- Socket and Hinge Joints
- Action of Antagonistic Muscles at a Hinge (Elbow) Joint
- Disorders of Skeletal System (Arthritis and Osteoporosis)

4.1 INTRODUCTION

The cells of an organism have a living material, protoplasm,which is sensitive, due to its sensitive nature it possess special property called irritability. It means it irritates when there is a change in its environment. Due to this irritability the living organism take some action to reduce its irritation these actions called movement. The change in environment takes place due to some factors these factors are called stimulus (stimuli: p). so we can say that movement is a response shown by living organisms toward stimuli. All living organism have property of locomotion due to nutrients, shelter and reproduction mainly plants are sessile while animals are usually motile therefore they respond to stimuli in different ways. Plant responds to stimuli by adjusting the rate of growth and osmotic condition. While respond to these stimuli by changing their position either towards or away from stimuli.

The movement can also occur at cellular level, like cyclosis in cell or the movement of chromosomes towards their respective poles during cell division etc.

On the basis of stimuli there are two types of movement

Autonomic or spontaneous movement	Paratonic or induced movement
It is due to internal stimuli i.e. cramps due to involuntarily release of Ca^{++} ions.	It is due to external stimuli i.e. reflex action.

Types of movement on the basis of responses.

Locomotory Movement or Taxis or Tactic Movement	Trophic Movement	Nastic Movement
• Types of movement where organism change its place either towards or away from stimulus	• Type of growth movement, organism move toward or away by growing their organs. • Usually found in plants, fungi or in bacterial colony.	• Type of movement where change in osmotic water occur due to stimuli.

• Usually found in animals, bacteria and protozoa.	• Growth of root towards water and mineral or growth of stem towards light.	• Purely found in plants like touch me not plant, which close leave when touch.

Difference between movement and locomotion

It is a misconception that locomotion and movement are the same phenomena. Movement is a broad term where organism response to stimuli in any way whereas locomotion is one of the type of movement where organism change its place takes place either towards stimuli or away from stimuli. If an organism show response towards stimuli but does not change its place it may be any type of movement but not locomotion.

4.2 SKELETON AND ITS TYPES

For locomotion animal body want support to change its place in a balanced and well-coordinated manner. For support animal have skeletal system. Skeleton are the frame work which gives shape to any structure. The skeleton performs three main functions

- Provide shape to organs
- Provide support to organs during movement
- Provide protection to soft, vital organs.

Types of skeleton

There are three main types of skeletons.

Hydrostatic Skeleton Hydro= water, static = to stay	Exoskeleton	Endoskeleton
• Skeleton made up of fluid.	• Skeleton deposit outside the body or organ.	• Skeleton develop inside the body.
• Found in soft bodied animal.	• Found in Arthropod, Mollusca and higher animals.	• Found in high animals.
• Simplest type of skeleton.	• It provide support and protection.	• Provide shape, support and protection.

• Help in extension or withdrawl of body or its organs. • In jelly fish, help in propulsion by water. • In earthworm, coelomic fluid work as hydrostatic skeleton.	• Nonliving in nature, in arthropods made up of chitin, in Mollusca made up of $CaCo_3$. • In high animals made up of proteins.	• Living in nature made up of cells. • Two types of endoskeleton cartilage made up of chondreocyte bones made up of osteocytes.

Human Skeleton

The skeletal system of human is basically made up of two types of skeletons

(i) Cartilage

(ii) Bones

Both are rigid, cellular structure and type of endoskeleton.

Cartilage	Bones
• Type of skeleton which is flexible	• Type of skeleton which is harder
• It is made up of cells called chondrocytes embedded in a matrix of protein called collagen.	• It is made up of cell called osteocytes embedded in a matrix of protein called collagen.
• It is much softer than bones as well as flexible.	• It is harder due to the deposition of calcium phosphate, process is called calcification.

• Calcification does not takes place.	• Calcification takes place.
• It covers ends of the bones and joints.	• It support the organ consists of an outer shell of compact bone.
• No blood vessel penetrate into cartilage.	• Blood vessels can penetrate into bone especially in spongy bones.

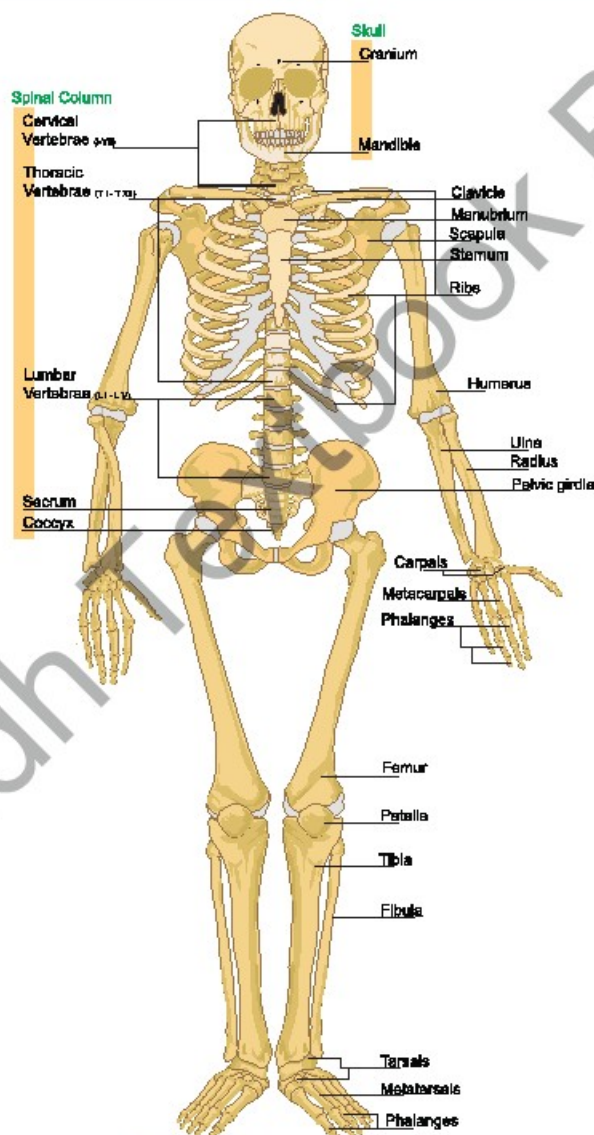



Fig. 4.1 Human Skeleton

4.2.1 Skeleton Provide Support and Movement

Skeleton provides support to the body, especially limbs. i.e. Hind Limbs and pelvic girdle provide support to the human body to be a bipedal animal, with these limbs the complete vertebrae of vertebral column provide support to stand straight. Cartilage of external pinna and nose support the organs to make their proper shape. Cartilages also support larynx, trachea and bronchi of respiratory system. It forms tough pads which acts as shock absorbers found in knee joints and also f orm intervertebral discs between vertebrae of backbone.

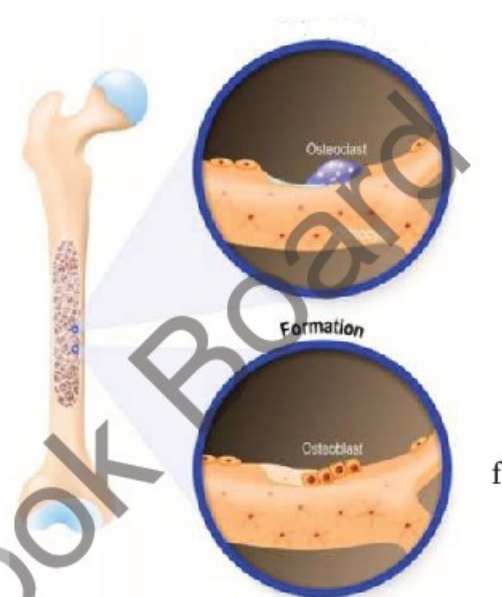



Fig. 4.2 Bone Forming Cells

4.2.2 Skeletal System is a Dynamic System

The dynamic property of skeletal system means that it is made up of living tissues, it is capable of quick growth. It can adapt to stress and can repair itself after damage (injury). 5% to 10% of our bones dissolve away annually and are replaced by a new one this process is called **remodeling** while in the growing age our bones enlarge with the growth of the body. The remodeling system allows a skeleton to alter the shape and size of skeleton in response to demands. e.g the bones carry heavy load or subjected to extreme stress become thicker to provide more strength and support. Normal stresses are major factors in maintaining bone strength.

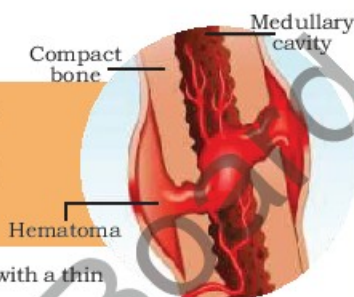
There are three types of cells associated with bones i.e. bones forming cells (**osteoblast**), mature bone cell (**osteocyte**) and bone dissolving cells (**osteoclast**).

Bone remodeling is the result of coordinated activity of osteoclast and osteoblast. This coordination can be seen clearly at the time of repair of broken bone.

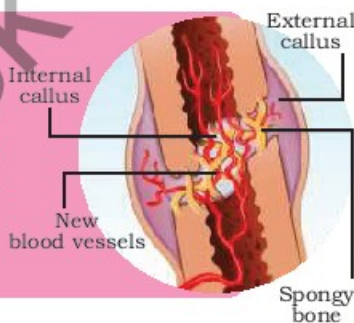
4.2.3 Model of Bone Healing Occurs During 6 Weeks.

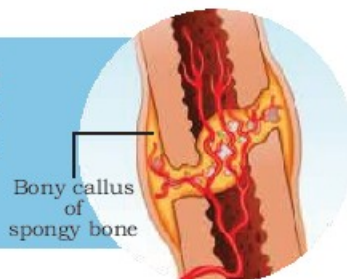
A bone is broken. Let's see the sequence of events occur during 6 weeks of bone healing.

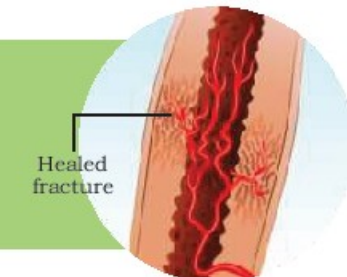
Step 1

Blood from reptured blood vessels form a large clot around the fracture. Phagocytic cells and osteoclast in the blood ingest, dissolved the Cellular debris and bone fragments.

*Bones are normally covered with a thin layer of connective tissues i.e. **periosteum**, rich in capillaries, osteoblast and osteoblast forming cells.

Step 2

A fracture ruptures the periosteum and stimulates the production and release of numerous osteoblasts, Which secrete a porous mass of bone and cartilage called callus, around break. Callus replaces the original blood clot and holds the end of the bones together, the remodeling process re-form the original shape of the bone.

Step 3

Osteoclast, osteoblast and capillaries invade the callus. Blood nourished the cells, osteoclast breakdown the cartilage while osteoblast replace it with bone.

Step 4

The healing of bone completed

4.3 Human Skeleton

In humans 206 bones are present which can be categorized into two groups.

(a) The axial skeleton
(b) The appendicular skeleton

The **axial skeleton** forms the main axis of the human body, includes the bone of the head (skull 22 bones), vertebral column (26 vertebrae) and rib cage (ribs 12 pairs and sternum 1 bone).

The **appendicular Skeleton** forms the appendages (Limbs) and their attachment to the axial skeleton includes pectoral (shoulder) and pelvis (hip) girdles.

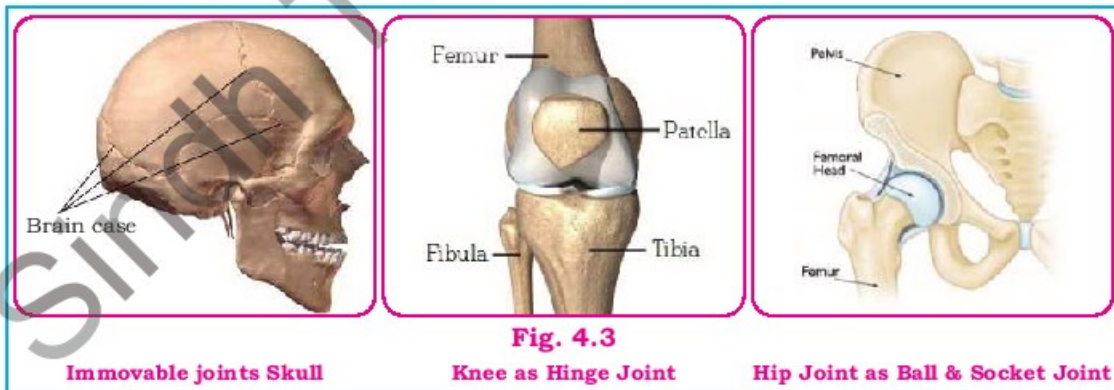
Pectoral girdle is consist of two bones i.e. scapula and clavicle. The forelimb consists of humerus, radius and ulna, carpal (8), metacarpal (5), and phalanges (14).

Pelvic girdle consist of three bones ileum, ischium and pubis.
Hind limb consists of femur, patella, tibia, fibula, tarsals (7), metatarsals (5) and phalanges (14).

4.4 JOINTS

The junction of two bones is called a joint. There are two types of joints. Immovable or fixed joint. Joint where bones are fixed like puzzle pieces and do not allow to move, like 8 bones of skull or 3 bones of pelvic girdles.

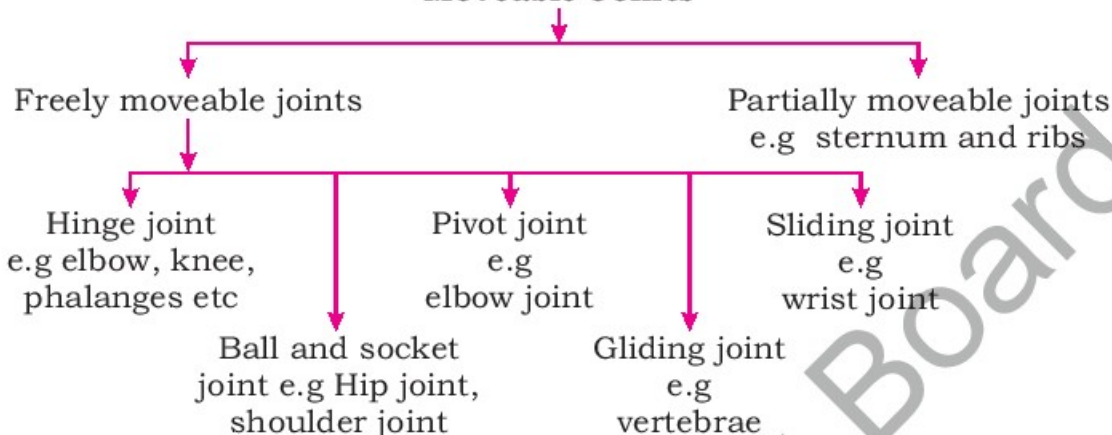
Fig. 4.3

Immovable joints Skull — Knee as Hinge Joint — Hip Joint as Ball & Socket Joint

Moveable joints where bones are allowed to move freely or partially. So there are two types of moveable joints i.e freely moveable and partially moveable.

Moveable Joints

- Freely moveable joints
  - Hinge joint e.g elbow, knee, phalanges etc
  - Ball and socket joint e.g Hip joint, shoulder joint
  - Pivot joint e.g elbow joint
  - Gliding joint e.g vertebrae
  - Sliding joint e.g wrist joint
- Partially moveable joints e.g sternum and ribs

Fig. 4.4

Elbow as pivot joint | Wrist as Sliding Join | Vertebral disc as gliding joint | Sternum & ribs as partially movable joint

Hinge Joints (e.g knee joint) allow movement in one plane only whereas ball and socket (shoulder joint) allow movement in many plans such as forward, backward and sideways. Both hinge joints and ball socket joints have the same basic structure.

4.4.1 Ligament and Tendon: Their Role in Movement

The band of fibrous connective tissues by which bones are joined to one another at joints called **ligament**. It works as strong firmly attached ropes, it stabilizes the joint r hold the ends of two bones ogether. The strong onnective tissue in the gaments protects these tructures and prevents them om bending twisting or earing.

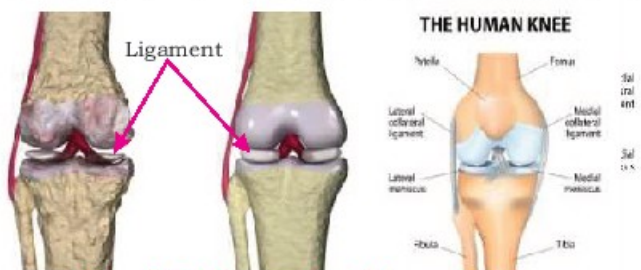



Fig. 4.5 Ligaments of knee joint

Skeletal muscles are attached to bones on either side of the joint by bands of tough, fibrous connective tissues called **tendons**. They are tougher and less elastic than ligaments. Tendon transfers the mechanical force of muscle contraction to the bones. It is strongly connected to muscles fiber at one end and to components of the bones at its other end. They are very strong, highly tensile.

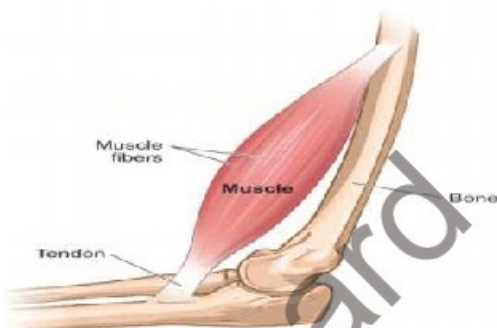



Fig. 4.6
Bone tendon of skeletal muscles

4.4.2 Location and Movement of Hinge Joint

Hinge joints move back and forth like the hinge on a door and allow movements in one plane only. The knee and elbow are hinge joints.

4.4.3 Location and Movement of Ball and Socket Joints

This joint allows movement in all directions. The ball of humerus and femur fit into the socket of pectoral and pelvic girdle respectively. The hip and shoulder joints are ball and socket joints.

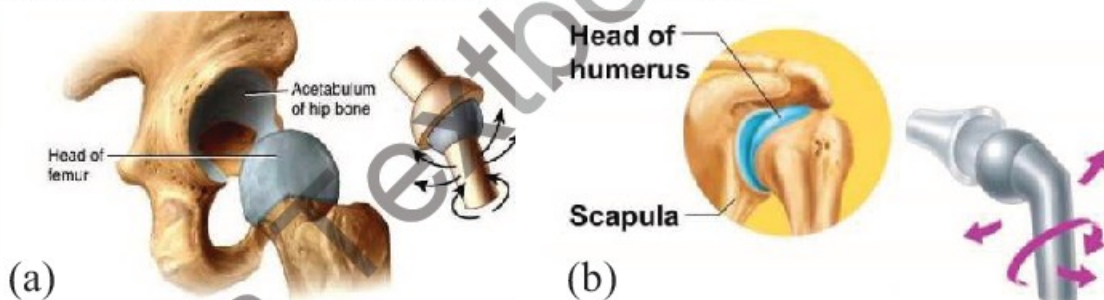



Fig. 4.7 Movement of Ball and socket of (a)Hip joint (b) Shoulder Joint

4.5 MUSCLES

Movements of arms and legs are brought about by the contraction of muscles attached to bones. Muscles are connective tissues consist of fibrous cells. These tissues have a tendency to contract and relax. The vertebrate possess three kind of muscles.

i. Skeletal muscles　　ii. Cardiac muscles　　iii. Smooth muscles

i. Skeletal muscles

The muscles which are attached to the skeleton called skeletal muscles. They are associated with the movement of bones. These muscles are voluntary in nature. They are also called striped or stride muscles because they have alternate thick and thin means dark and light bands.

ii. Cardiac muscles

These are the muscles which build the walls of heart. They are also striated muscles but unlike skeletal muscles they are branched in nature and arranging mash work. They are involuntary in nature, work under the control of SAN (Sino auricular node).

iii. Smooth muscles

Smooth muscles are the earliest form of muscles from evolutionary point of view. They are made up of long and spindle shaped cells, each cell contain single nucleus. They have no striations or stripes. They are involuntary in nature. These muscles are found in blood vessels, digestive tract and many other internal organs.

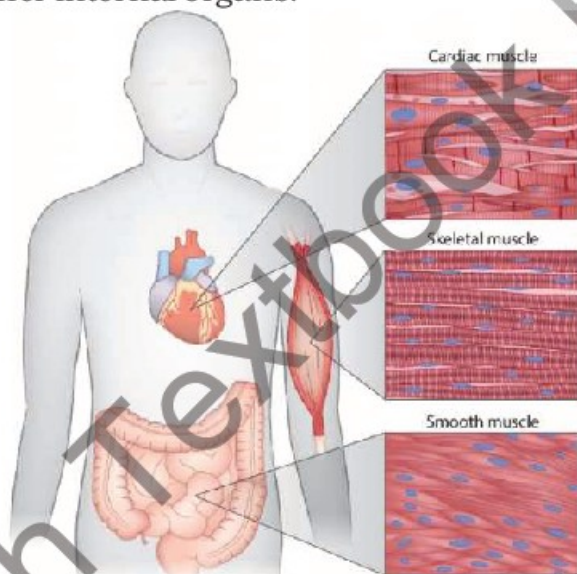



Fig. 4.8 Muscles

Support and locomotion is mainly due to skeletal system and skeletal muscles system. The contraction and relaxation of skeletal muscles allows the bones to move. The muscles which are attached with bones are called **skeletal muscles**. These muscles only exert a pulling force. When skeletal muscles relax, they are stretched by the contraction of another muscles. It shows that muscles are always found in pairs. The one muscle of this pair when contracted other muscles will relax. This type of working of two muscles against each other called **antagonism**. The pair of skeletal muscles which work against each other called an **antagonistic pair**. The action of **biceps** and **triceps** muscles of arm is a good example of an antagonistic pair.

The bicep muscle is a large muscle that lies on the front of the upper arm between the shoulder and elbow. It has two heads or origin. The tricep is also a large muscle on the back of arm. It is three headed or origin.

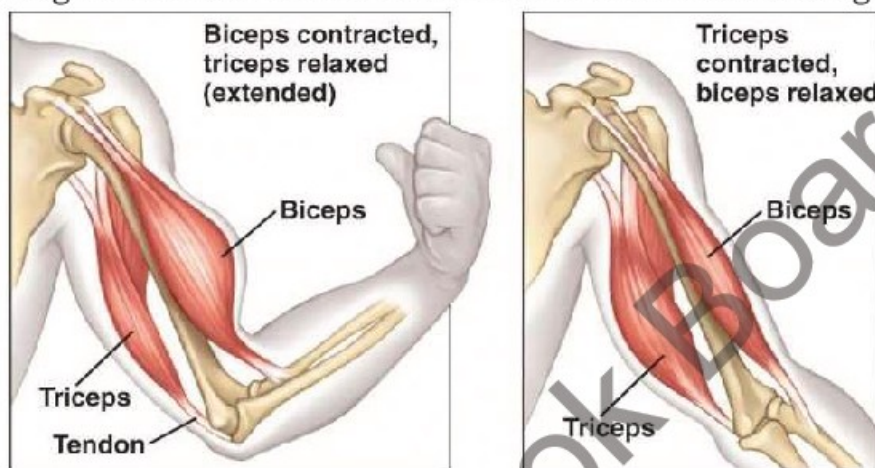



Fig. 4.9 Bicep and Tricep muscle work as Antagonistic muscles of arm

When the biceps muscle contracts it pulls upon the radius bone of lower arm, which bend the arm at elbow, this bending process is called **flexon**. On the other side when triceps muscle contracts it pull on the ulna which straightens or extends the arm. The straighten process is called **extension**. It shows that when the biceps contracts the triceps relaxes and vice versa. It means that in arm the biceps is the **flexor** muscle and **tricep** is the extensor muscle.

4.6 DISORDER OF SKELETON SYSTEM

4.6.1 Effect of Calcium Deficiency on Bone

The hardening of bones occurs due to deposition of calcium phosphate, this process is called calcification. If Ca^{++} deficiency occurs in body or blood, ultimately it occurs in bones. This deficiency of Ca^{++} in bone is called hypocalcemia known as calcium deficiency disease. A long term calcium deficiency can lead to dental weakness, osteoporosis, in childhood rickets.

Osteoporosis is a disorder related to the aging process. In this condition the bones become porous or more spongy, thinner and weaker so that they become fragile, in this condition a slight injury break the bone. Osteoporosis is more common in female than male.

Rickets

Rickets is the softening and weakening of bones in children, usually because of an extreme and prolonged vitamin D deficiency. Vitamin D

plays vital role in the absorption of Ca^{++}, deficiency of vitamin D leads to deficiency of Ca^{++} in bone.

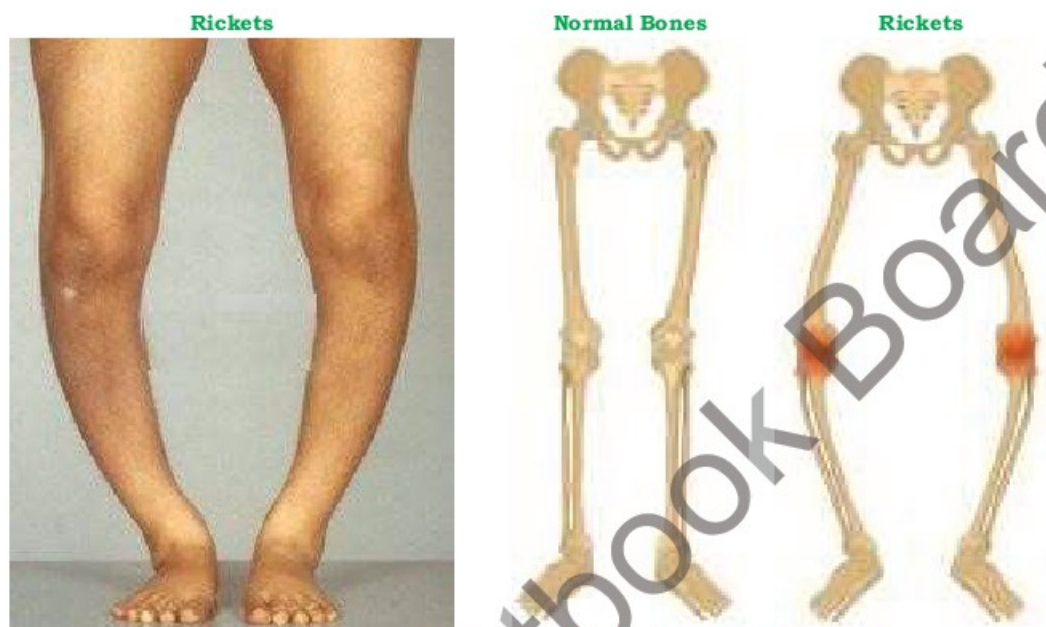



Fig. 4.10 Calcium deficiency develop rickets in children

4.6.2 Arthritis

It is the painful condition of joints due to swelling and tenderness of joint. The main symptom of arthritis are

- Joint pain
- Tenderness and stiffness
- Inflammation in and around the joint
- Restricted movement of joint
- Warm red skin over the affected joint
- Trouble dressing, combing, gripping, bending over squatty or climbing stair.

Fig. 4.11 Arthritis in knee as inflammation of joint

Common types of Arthritis

Osteoarthritis	It is a "wear and tear", **causes**; overuse of joints, age, joint injury, obesity. Joints that bear weight, like knees, hips, feet and spine.
Rheumatoid Arthritis	It is due to immune system i.e. autoimmune disorder. In this disorder immune system attacks on joints.
Psoriatic Arthritis	In this disorder joints and skin affects.

Causes of Arthritis

The following factors are the causes of arthritis.

- Injury
- Abnormal metabolism
- Infection
- Auto immune system
- Genetic makeup
- Reduction in the normal amount of cartilage or synovial fluid

Role of obesity in arthritis

Obesity puts stress on joints, especially on knee, causing pain and develop worse condition in arthritis damage. The rheumatologist states that just 10 pound overweight increases force of 20 to 40 pound on knees at each step during walk.

The excessive fats tissues release high levels of cytokines proteins that can cause inflammation throughout body. The same protein produced by joints during rheumatoid arthritis. It makes existing joint inflammation more worse.

Fig. 4.12
Obesity as one of the cause of arthritis

SUMMARY

- Movement is the action taken by living organism to reduce its irritation.
- Locomotory movement require skeletal system, Muscular system
- Skeleton can be defined as frame work which gives shape to any structure.
- Skeleton provides support to the body, especially limbs. i.e. Hind Limbs and pelvic girdle.
- Cartilages also support larynx, trachea and bronchi of respiratory system.
- There are three types of cells associated with bones i.e. bones forming cells (**osteoblast**), mature bone cell (**osteocyte**) and bone dissolving cells (**osteoclast**).
- In humans 206 bones are present which can be categorized into two groups.
- The junction of two bones is called a **joint**.
- There are two types of joints. Immovable or fixed joint. Joint where bones are fixed like puzzle pieces.
- Hinge Joints (e.g knee joint) allow movement in one plane only whereas ball and socket allow movement in many plans.
- The band of fibrous connective tissues by which bones are joined to one another at joints called **ligament**.
- The strong connective tissue in the ligaments protects these structures and prevents them from bending twisting or tearing.
- Skeletal muscles are attached to bones on either side of the joint by bands of tough, fibrous connective tissues called **tendons**.
- This type of working of two muscles against each other called **antagonism**. This pair of skeletal muscles which work against each other called an **antagonistic pair**.
- This bending process is called **flexon**. Straighten process is called **extension.**
- A long term calcium deficiency can lead to dental weakness, osteoporosis, in childhood rickets.
- Osteoporosis is a disorder related to the aging process
- Rickets is the softening and weakening of bones in children, usually because of an extreme and prolonged vitamin D deficiency.
- Arthritis is the painful condition of joints due to swelling and tenderness of joint.
- Obesity puts stress on joints, especially on knee, causing pain and develop worse condition in arthritis damage.

EXERCISE

A. MULTIPLE CHOICE QUESTIONS

Choose the correct answer:

i) Irritation caused by stimulus is the main cause of
(a) Tropism (b) Movement
(c) Locomotion (d) Arthritus

ii) The frame work which gives shape to any structure called
(a) Architecture (b) Bone
(c) Cartilage (d) Skeleton

iii) The cartilage are made up of cells called
(a) Osteoclast (b) Osteocytis
(c) Chondrocytes (d) Chaonocytes

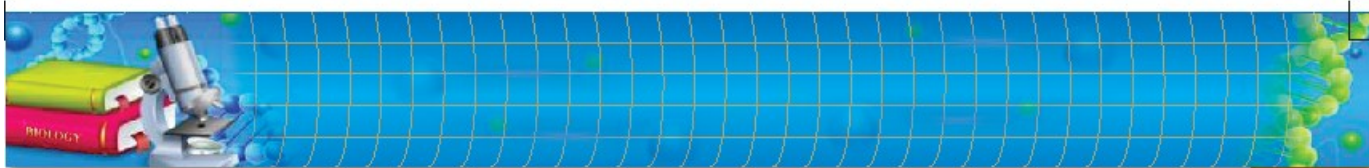
iv) The head of femur attached with
(a) Pelvic girdles (b) Pectoral girdle
(c) Scapula (d) Acetabulum of pelvic gridles

v) The large muscles of arm is
(a) Bicep (b) Tricep
(c) Tetracep (d) Pentacep

vi) The band of tough, fibrous, connective tissue which are attached to bone at joints called
(a) Ligament (b) Tendon
(c) Bicep (d) Tricep

vii) Softening and weakening of bone in children due to deficiency of vitamin D called
(a) Osteoporesis (b) Osteoarthritis
(c) Rickets (d) Rheumatic fever

viii) The muscle which is responsible to straighten the limb is
(a) Ligament (b) Skeleton muscle
(c) Flexor (d) Extensor

ix) The pair of muscle where both work in opposite direction
(a) Antagonist (b) Cardiac
(c) Smooth (d) Abductor

B. SHORT QUESTIONS:

i) What are the main functions of skeleton?
ii) Distinguish between bone and cartilage.
iii) Locate the cartilages in different organs.
iv) Enlist the name and number of bones present in hind limb.
v) Locate the immovable joints in the human body.
vi) Draw neat and labeled diagram of hinge joint and ball and socket joint.
vii) What is ricket? Give its causes.
viii) Distinguish between ligament and tendon.
ix) Locate hinge joint in the body of human
x) What do you mean by bicep and tricep muscles?

C. EXTENSIVE RESPONSE QUESTIONS:

i) Prove that the skeletal system is s dynamic system
ii) Describe the flexon and extension in human arm
iii) Explain disorders of bones and their causes.

Chapter 5

REPRODUCTION

Major Concept

In this Unit you will learn:

- Introduction
- Reproduction in Plants
  - ★ Asexual Reproduction in Plants
  - ★ Sexual Reproduction in Plants
- Asexual Reproduction in Animals
- Sexual Reproduction in Rabbit
  - ★ Male Reproductive System
  - ★ Female Reproductive System
- Population Planning
- Sexually Transmitted Diseases (AIDS)

5.1 INTRODUCTION

The living organism performs so many vital processes. One of the processes where living organisms produce offspring of their own kind is called reproduction. Reproduction is the most fundamental function of living things. It is essential for continuing and survival of the species. An individual will not die if it does not reproduce but there is a danger of extinction, if does not reproduce regularly. First the species becomes endanger due to low rate of reproduction and finally vanish if not reproduce. Many species of plants and animals are in danger of vanishing because man use them or kill them in such large number which cross the limit of its rate of reproduction. Sometimes changes in the habitat of an organism due to the different activities, organism do not feel comfortable to reproduce. It means the reproduction also depends on the favorable environmental conditions also.

5.2 TYPES OF REPRODUCTION

Living organism can produce by two ways

(i) Asexually
(ii) Sexually

Asexual Reproduction	Sexual Reproduction
• Type of reproduction which takes place without fusion of male and female gametes(sex Cells).	• Types of reproduction which takes place by the fusion of male and female gamete (sex cells).
• In this type of reproduction only one parent is involved.	• In this type of reproduction usually two parents of opposite sexes are involved.
• The off springs are exactly similar to their parent.	• The off springs are not exactly similar to any one of the parent.
• Organisms are genetically similar to each other as well as to their parent.	• Organisms are genetically dissimilar to each other as well as to their parent.
• No new combination of genes (genetic recombination) occurs.	• Genetic recombination occurs which causes variation and leads to evolution.

5.2.1 Asexual Reproduction in Protists, Bacteria and Plants

The bacteria, protists and plants reproduce asexually by a number of methods, whereas Bacteria only reproduce by asexual reproduction.

Some of the asexual methods of reproduction in plants are described below.

(i) By Fission (Splitting):

The splitting of cell into two or more cells is called Fission. It is the simplest and the fastest mode of asexual reproduction during which there is replication of genetic material (Prokaryotes) or division of the nucleus (Eukaryotes) followed by division of cell (parent body) into independent daughter cells. Each daughter cell receives equal amount of nucleic or genetic material. Fission is of two types. i.e. binary fission or multiple fission.

(a) Binary Fission:

Type of fission where a mother cell divides into two daughter cells. It occurs during favorable conditions. It takes place in bacteria under favorable conditions of temperature, nutrition and moisture, single bacterium divides into two bacteria within 20 minutes and numerous bacteria are produced within very short interval of time.

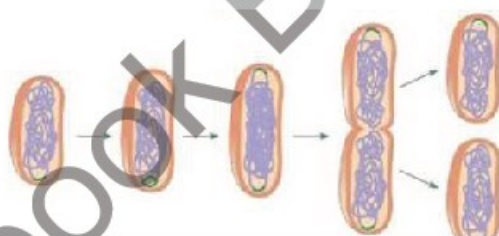



Fig. 5.1 Binary Fission

a) Multiple Fission:

Type of fission where a mother cell divide into more than two daughter cells

(ii) Budding:

In this type of asexual reproduction the parent cell forms a small out growth which is called bud. This bud detach from parent cell or body and grows into new organism. It takes place in yeast and plants.

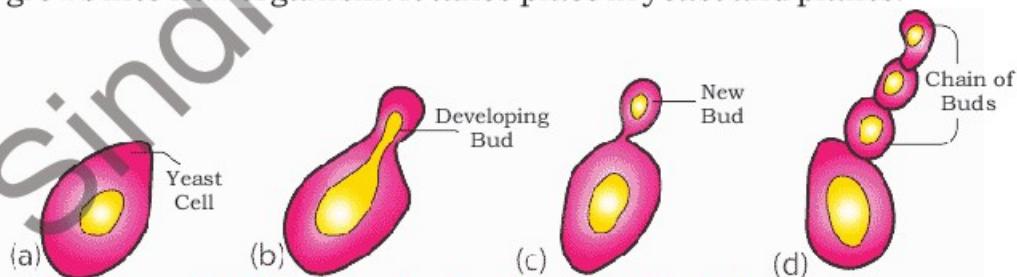



Fig. 5.2 Reproduction in yeast by budding

(iii) By Spores

In fungi, algae and plants asexual reproductive structure sporangium is developed on their body. These sporangia produce numerous unicellular spores. Spores are very small and light usually they

dispersed by wind. Spores have thick, resistant walls which enable them to survive in unfavorable conditions. When these spores drop on proper substratum, they develop into new organism in favorable conditions.

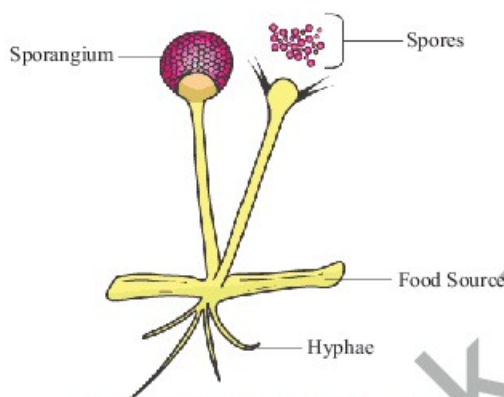



Fig. 5.3 Spore formation

(iv) Vegetative Propagation

Vegetative means non-reproductive part of plant like, thallus, root, stem and leaf. If any of this part develop into new plant called vegetative propagation. These parts sooner or later separated from parent plant. These specialized vegetative organs are morphologically different in different cases but usually in all cases they bear one or more bud which develops into new plants.

Runner (Grass and strawberry) stolen (mint), rhizomes (ginger)
Bulb (onion and garlic), stem tuber (potato), Bulbil (Bryophyllus)
Root tubers (sweet potato), Phylloclades (Opuntia)

The vegetative reproduction in most cases is due to accumulation of large amount of reserve food and consequent growth of the vegetative parts.

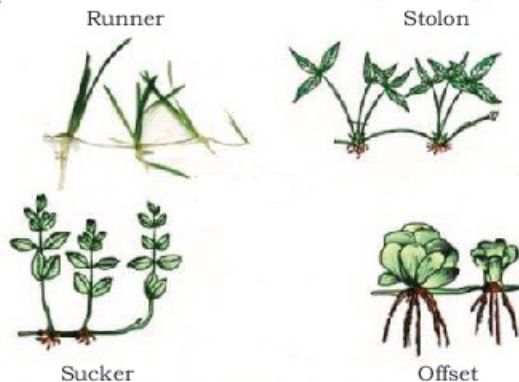



Fig. 5.4 Vegetative propagation in plants

Vegetative Propagation	Artificial Propagation
• It is natural development of new plant without human efforts. • Natural vegetative propagation usually occurs by root, stem, or leaves. • Stem; Runners grow horizontally above the ground. • Roots; new plant emerges out of swollen modified root known as tuber. • Leaves; of a few plants detached from parent plant and develop into new plant e.g. Bryophyllum.	• It is the method of development of new plant with the help of human efforts. • Artificial propagation can occur from cells, tissues, cutting of stem etc. • The method are Tissue culture, Cutting, Grafting, Layering, Budding • Root may be used for artificial propagation • Any leave tissue may also use for artificial propagation.

5.2.2 Vegetative Propagation in plants (through stem, suckers and leaves)

New plants can be produced from vegetative structures such as the roots, stems, suckers and leaves. The process can be natural or artificial.

By Stem:

In many plants, the stem has buds as in onions, daffodils and strawberries etc. have stems that can start new offspring. These type of stem that can reproduce recognized as runners, bulbs, rhizome, tubers, and suckers.

Fig. 5.5 Vegetative propagation by stem

Leaves:

Some leaves have bud on their margin e.g. Bryophyllum. These buds give rise adventitious root when fall on ground or come in contact with soil. After some time these parts of leaves develop into an independent plant.

Fig. 5.6 Bryophyllum

Suckers:

Suckers are known as root sprouts, basically these are plants stem that arise from buds on the base of stem or root of parent plant that use suckers, are apple, elm and banana tree. Suckers grow and form a dense compost mats that is attached to parent plant. Too many suckers can lead to a small crop.

Fig. 5.7 Sucker

5.5.3 Methods of Artificial Vegetative Propagation:

Plants have unique feature that they possess growing or embryonic centers in the form of bud. Due to these embryonic centers, plants are capable of farming new plants. The man has exploited it to reproduce desired type of plants by artificial propagation. It takes place by cutting, grafting and cloning.

Cutting:

Cuttings are the short pieces of stems that have 2 to 3 nodes and buds. It cuts obliquely below a node from a plant. The cutting embedded in soil with at least one node above the soil. The adventitious roots and shoots grow from buds of the portion below the soil and above the soil respectively forming a new plant e.g. sugar cane, sweet potato and rose.

Fig. 5.8 Cutting of Sugarcane

Grafting:

This is a technique where a branch of desired variety of plant is joined to another plant with well-established root system. The plant from which the branch is taken is called **scion** and the plant to which it is joined is called **stock**. The two plants involved are normally belongs to different varieties of same species e.g. oranges, lime and mango.

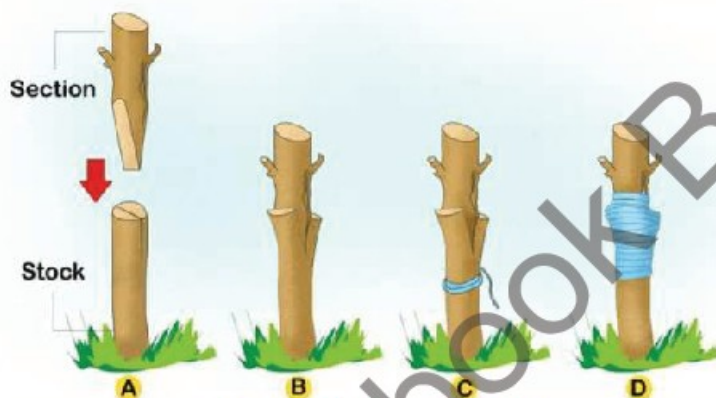



Fig. 5.9 Grafting of plant

Cloning (Tissue Culture Technology)

It is one of the recent techniques. In this method tissues of selected plants are cultured using their ability of asexual reproduction in test tube or dishes. To speed up the growth, hormones are added in the growth medium. After some time the baby plant is transferred to field for large commercial scale production of desired yield.

5.2.4 Apomixes (Parthenogenesis) is the type of asexual reproduction:

Apomixes is the type of seed production without fusion of male and female gametes. It is the type of Parthenogenesis which is the form of asexual reproduction. Where an egg develops into a complete individual without being fertilized. The resulting offspring can be either haploid or diploid depending on the process and the species. It is a natural form of asexual reproduction in which embryo develops in the absence of fertilization. Most commonly found in plants and invertebrates. The question arises here when gamete is involved so why it is considered as asexual reproduction? Because this process does not require fusion of male and female gametes to produce offspring and new genetic combination does not occur.

5.2.5 Sexual Reproduction in flowering Plants

The angiosperm is the group of plants which gives rise traditional flower therefore these plants are called flowering plant. In these plants sexual reproduction takes place through flower. Flower is highly modified shoot which is responsible for the reproduction by producing seeds within fruits.

Angiospermic flower has two external wheels of leave called **calyx** and **corolla** which consist of **sepals** and **petals,** respectively. The **androecium** and **Gynoecium** are two inner wheels of leaves i.e. **stamen** and **carpels** respectively; which are directly responsible for sexual reproduction of plants. Stamen produce pollen **grains** and carpel produce **ovule** in ovary.

Fig. 5.10 Parts of a flower

Structure of Ovule:

Each ovule has main cellular body called **nucellus**. It is surrounded by two coats, outer and inner integuments. A small opening present at the apex of the integument is called **micropyle**. The ovule has stalk, the **funicle** with which it is attached to ovary wall. **Chalaza** are tissues between nucellus and funicle.

There is a large oval cell embedded in the nucellus which form embryo sac (female gametophyte). The mature embryo sac consists of 7 cells i.e. one Ovum, two synergids,

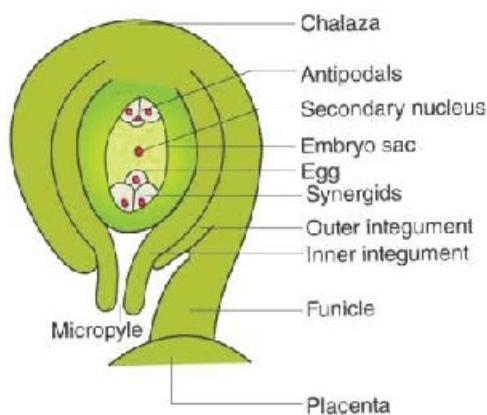



Fig. 5.11 Structure of ovule

three antipodals cells and one secondary nucleus in numbers while a diploid cell is a fusion nucleus in the center.

Structure of pollen grain:

Pollen grain develops in pollen sac of anther form microspore in the form of loose, dusty powder. Each pollen grain is 4 celled structure, bounded by wall which consists of 2 layers, outer, the **exine** and inner, the **intine.**

In angiospermic plants the main plant is sporophyte which consists of **vegetative** and **floral** parts. The vegetative parts are root, stem and leaves while flower, fruit, seed are floral parts which develop from flower. The floral part is reproductive part. After two processes i.e. pollination and fertilization, it produces seed within fruit. The seeds when disperse germinate into baby plant called **seedling**, when matures, it become a new plant like its parents.

In flower androecium (male part) is consist of stamen (microsporophyll) has 2 to 4 pollen sac (microsporangia) in its anther. These pollen sac are filled with microspore mother cell which produce microspore by meiotic cell division. Each unicellular microspore divide its cells by mitosis and produce 2 to 4 cells, in this way unicellular microspore become pollen grain (multicellular) but each of its cell is haploid. When anther burst these pollen grains disperse in nature.

Fig. 5.12 Structure of pollen grain

On the other hand each carpel (megasporophyll) has one or more ovules (megasporangium) in its ovary. Each ovule has single megaspore mother cell. This megaspore mother cell divided by meiosis to produce 4 haploid megaspores. Only one will survive and develops into embryo sac (female gametophyte) inside ovule, which consists of 7 cells as discussed earlier. The pollen grain disperse if dropped at the stigma of carpel the life cycle remain continues. Now the question arise how pollen grain transferred to stigma and what is it called.

5.3 POLLINATION

Pollination is the process in which pollen grains are transferred from anther to stigma of carpel.

5.3.1 Types of Pollination

(i) Self pollination
(ii) Cross pollination

(i) Self Pollination

It is the transfer of pollen grains from anther of stamen to the stigma of same flower or flowers on same plant.

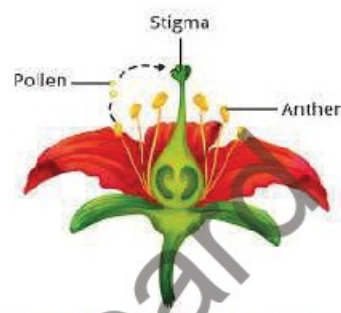



Fig. 5.13 Self pollination

(ii) Cross Pollination

It is the transfer of pollen grains from anther of one flower to stigma of other flower belongs to another plant of same species.

Cross pollination is more common than self-pollination, the pollen grains are carried from one flower to another flower through following agents.

(i) Wind
(ii) Water
(iii) Insects
(iv) Animals

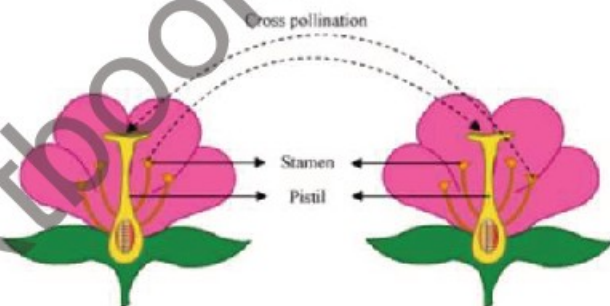



Fig. 5.14 Cross pollination

When pollen grain drops at stigma, it starts its development into pollen tube (male gametophyte), which consists of 6 haploid cells, among them two are prothallial cells, two are male gametes, one stalk nucleus and one tube nucleus. The pollen tube grows from stigma to ovule through style and transfers two male gametes in ovule through micropyle which ultimately reach to embryo sac. One sperm nucleus fuses with ovum to produce diploid (2N) zygote while other gamete fuses with secondary nucleus to form 3N (Triploid) cell which later develop into endosperm of seed. This type of fertilization is called **double fertilization** which is the characteristic feature of angiospermic plant.

The 2N zygote after successive mitotic divisions develops into an **embryo** within the embryo sac, whereas triploid (3N) secondary nucleus develops into **endosperm**. The endosperm provides nourishment to the developing embryo.

During this development the ovule develops into **seed** the integument develop into **seed coat** whereas zygote form small embryo and cotyledon during this the ovary outside ovule become swollen due to mitotic cell division and become **fruit**. The fruit is eaten by animal or decay, the seeds come out, disperse or dropped in soil. In favorable conditions, it germinates and grows into new baby plant

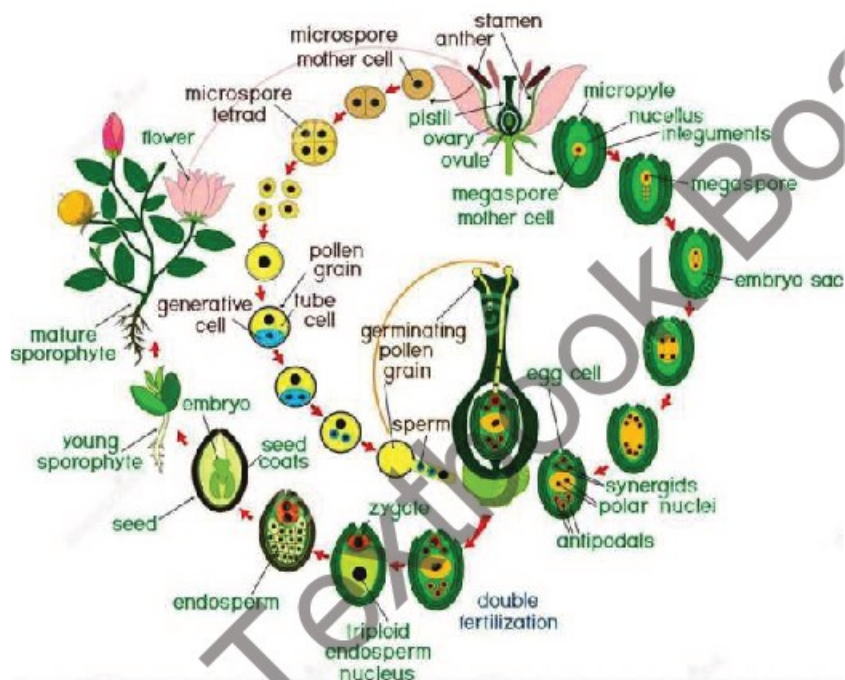



Fig. 5.16 Life cycle of flower

Fruit Formation

The ovary enlarges to form a fruit, containing seed or seeds. The stigma and style disappear. The stamens and petals are usually lost after pollination. In some cases, sepals remain attached with fruit e.g. brinjal. The endosperm provides nourishment to develop embryo. It also stores energy in grains like wheat, rice, gram etc. which can be utilized by us or other animals.

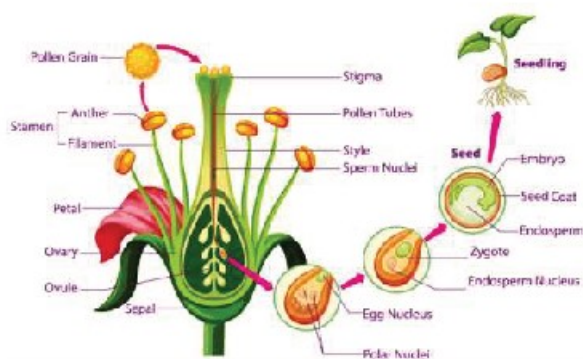



Fig. 5.16 Fruit formation

Formation of fruit with out fertilization

Fruit and seed formation usually occur after fertilization but some fruit may formed without fertilization. This mechanism is called **parthenocarpy** i.e formation of seedless fruit, like banana.

5.3.2 Adaptation in the structure of wind pollinated and insect pollinated flowers.

Some plants spread their pollen grains by wind and H_2O while the other spread by insects and animals. The plants which spread their pollen grain by wind and H_2O have some adaptive characters.

Adaptive characters of wind and water pollinated plants.

1. The flowers of these plants are non- attractive, small in size and do not bear any odour.
2. They produce pollen grains in high quantity.
3. The pollen grains are very light in weight, some of them bear wings and some have parachute like structure.
4. They do not produce high quantity of nectar.

Adaptive character in insect pollinated plants.

1. The flowers are large in size.
2. They have bright coloured petals or sepals or bracts.
3. The pollen grains have sticky substance or hooks.
4. They produce special odour
5. They produce high quantity of nectar.

5.3.3 Seed and its structure

Seed may be defined as ripened ovule or it is fertilized, developed ovule which contains dormant embryo.

The seed consists of following parts:

1. Seed Coat
2. Embryo
3. Cotyledon
4. Sometime endosperm

The outer wall of seed which develops from integument of ovule called seed coat. The seed coat consists of an outer thick layer called **testa** and inner thin wall called **tegmen**. The embryo develops from diploid zygote. It is a small axis, lying between two cotyledons, the upper end called **plumule** and the other lower end

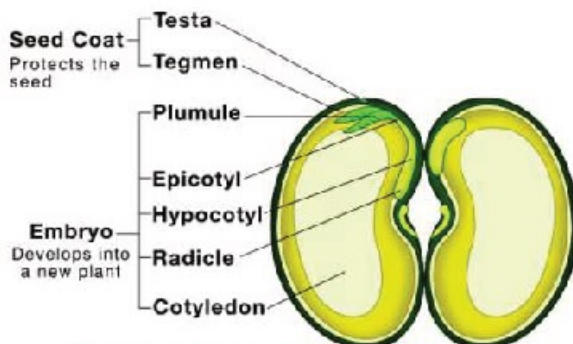



Fig. 5.17 Structure of bean seed

is called **radicle**, during germination plumule develops into shoot while radicale develops into root. The seed also contains leaf-like structure called **cotyledon**. These are either one or two on the basis of these numbers the seeds are classified into **monocot** or **dicot** seed, respectively. In endospermic seed these cotyledons are thin and paper like. In many of the seeds endosperm is not present than food is stored in cotyledons therefore they become swollen and thick e.g pea. The hilum is a scare, present at seed coat. The water enters into the seed through a very small hole in the seed coat this pore is called **micropyle**.

In some monocot seeds, ripened ovary walls called **pericarp** get fused permanently with seed coat as found in maize grains. Internally maize grain is divided into two unequal parts by a thin layer of cells called **epithelium**. The larger portion is he **endosperm** and the smaller is **mbryo**. In the embryonic part, a hield shaped cotyledon is present alled **scutellum**. Moreover the lmule and radicle are enclosed in rotective sheath called **coleoptile** nd **coleorhiza,** respectively.

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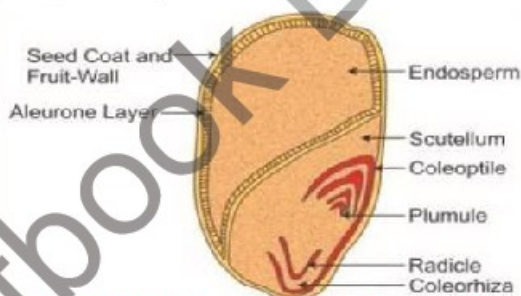


Fig. 5.18 Structure of maize grain

5.3.4 Germination of seed

Breaking of seed dormancy is called seed germination. As a result of germination seed develops into seedling.

Conditions necessary for seed germination

Only living seeds can germinate, require optimum condition of moisture, oxygen and temperature.

(i) Role of water (Moisture)

Water is essential for life because metabolic activities depend on water. Seed coat become soft by water. Cotyledons and endosperm absorb water by imbibition become swollen and exert pressure on seed coat to break. So the embryo comes out to grow, enzymes become activated by water and solid reserve food change into solution.

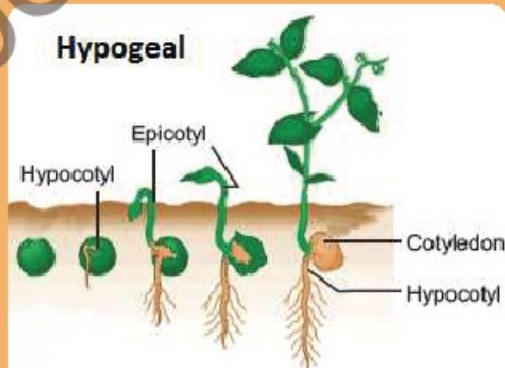
(ii) Role of oxygen:

The metabolic activities require energy. Energy is produced during respiration which requires oxygen.

(iii) Temperature:

Enzymes activity require certain range of temperature. Most of the seeds require the temperature range between 25 to 37°C. Seeds do not germinate at temperature below 0°C or above 45°C.

Types of germination

Epigeal Germination	Hypogeal Germination
Epi = above, geo = earth The type of germination where seeds come above the soil during germination.	Hypo = below, geo = earth The type of germination where seeds remain in the soil during germination
The growth rate of hypocotyl is higher than epicotyl.	The growth rate of epicotyl is higher than hypocotyl.
The hypocotyl grow in the form of arch.	The hypocotyl does not grow in the form of arch.
The cotyledons become green when come above the soil and work as 1st foliage leaves.	The cotyledons do not turn green.

5.4 REPRODUTION IN ANIMALS

There are also two types of reproduction in animal. i.e. Asexual and sexual reproduction.

5.4.1 Asexual reproduction

Animals reproduce asexually by different methods, some of them are as follows.

(i) Fission (Splitting)

Splitting of cell into two or many cells or organisms called fission.

(a) Binary Fission:

The type of fission where an organism divides into two organisms is called binary fission. It is commonly observed in unicellular organisms like protozoa. During this process the nucleus of the parent organism divides into two nuclei, both of them move in opposite directions in the cytoplasm. Meanwhile, a constriction appears in cytoplasm which deepens from outside to inside finally organism divides into two organisms.

(b) Multiple Fission

Multiple fission involves the division of an organism into many small sized daughter organisms as found in *Plasmodium.*

(ii) Budding

In this method one or more out growth develop on the body surface of organism which are called buds. When buds separates from the parent body starts living independently and develop into new organism e.g. *Hydra*.

(iii) Fragmentation

It is found in lower, multicellular animals like liver fluke and nematodes. When a living organism divides into fragments, each fragment recovers its lost part by regeneration and develops into new organism.

5.5 SEXUAL REPRODUCTION

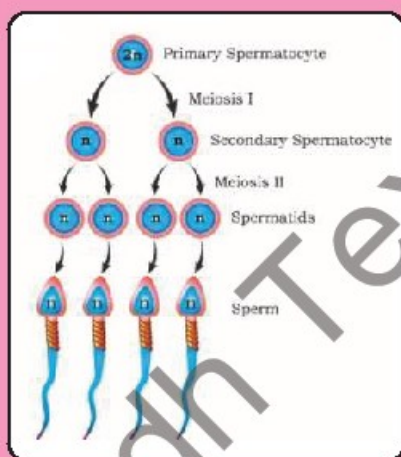
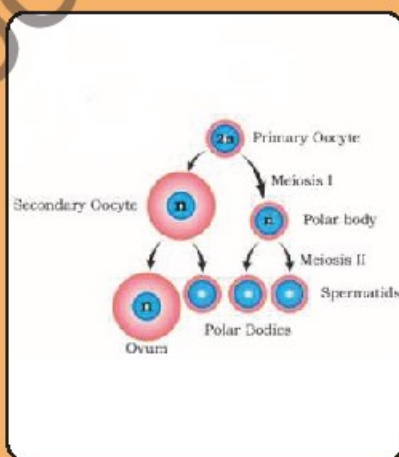
The process of sexual reproduction involves fusion of specialized haploid sex-cells or gametes to form a single diploid cell, **zygote**. The fusion of these gametes is called **fertilization**. Sexual reproduction involves:

(i) Gametogenesis - Formation of gametes
(ii) Mating - Union of male and female organisms to collect their gametes at same place.
(iii) Fertilization - Fusion of male and female gametes to form zygote.

5.5.1 Gametogenesis in Rabbit:

Gametogenesis is the process of gametes formation by meiosis in gonads.

These are two types.

Spermatogenesis	Oogenesis
Formation of sperm in male gonads (Testis) from germ cells.	Formation of ovum in female gonads (ovary). The process of gametes formation or gametogenesis involves meiosis, which reduces number of chromosomes to half in gametes. It also results variation in genes by process called **crossing over** .These gametes mostly do not have identical genetic make up.

5.5.2 Male and Female reproductive Organs in Rabbit

	Male	Female
Gonads (Gametes producing organs)	• Testes two in numbers • Hanging outside, in a sac called **scrotal sac**. • Contain seminiferous tubules • Epididymis to collect sperm	• Ovaries two in numbers • Located in abdominal cavity • Produce ovum
Duct (Gametes collecting tubes)	• Vas deferens, two in number.	• Oviduct or fallopian tube collect ovum from ovary. • Two in number
Genitals (Gametes depositing or receiving organs)	• Penis, a muscular organ to transfer semen into female genital	• Vagina, a tube which receive semen containing many sperms
Glands	• Prostate gland • Cowper's gland • Seminal vesicle	• Ovary works as gland as well

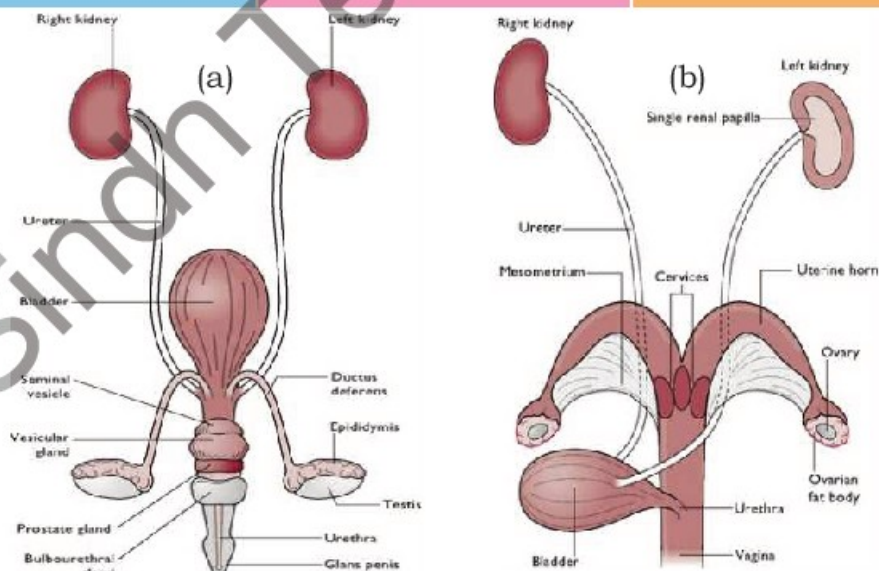



Fig. 5.19 Reproductive organs of rabbit (a) Male (b) Female

5.5.3 Fertilization

The process of fusion of male and female gametes from diploid zygote is called **fertilization**. On the basis of location of fertilization there are two types of fertilization, **external** and **internal** fertilization.

External Fertilization	Internal Fertilization
• It takes place outside the body. • It takes place in water. • Both gametes mature at same time. • Gametes are produced in large numbers. • It takes place in fishes and amphibians.	• It takes place inside the body of female. • It takes place inside female body. • Gametes may mature after each other. • Gametes are produced in limited numbers. • It takes place in reptiles, aves and mammals.

5.6 NEED OF POPULATION PLANNING

Population planning is the policy to limit the growth in number of population especially in those countries which has limited resources or in densely populated part of earth.

Population means the total number of beings living in a particular area. The human population helps in estimating the birth and death rates, the number of resources that will be required i.e. food, houses, health, electricity, transport, drinking water, garbage disposal etc.

In the modern world people wants to live quality life, better health facilities and jobs. The average is higher than before which is leading to an increase in the population. An increase in population can cause strain on the resources due to high demands. This strain can lead to environmental disturbance.

To establish and maintain the quality of human life and environmental conditions the birth rate should be planned according to available resources of the area. It is necessary that the birth and death rates balances each other to maintain sustainable population growth. China and India are considered as overpopulated countries. It means that their population exceeds their caring capacity resulting in depletion of resources and threatening environment. United Nations and other world organisations formulated certain policies and strategies to keep a check on increasing population.

5.7 SEXUALLY TRANSMITTED DISEASES

The diseases or infections which are passed from one person to another person through genital organs and genital fluids during sexual contacts called **sexually transmitted diseases**. Sometimes they can spread through intimate physical contact as well like herpes, spread by skin to skin contact. Some of the sexually transmitted diseases are Gonorrhea, AIDS, Syphilis, Genital herpes etc.

Sexually transmitted infections have been known since ancient time, they remain world wide a major public health problem. AIDS is one of the serious threat came into light around 1980.

AIDS (Acquired Immuno Deficiency Syndrome) is caused by virus known as HIV (Human Immuno-deficiency Virus). The HIV is transmitted through contaminated surgical instruments, transfusion of infected blood, sexual contacts, placenta and mother's milk.

Role of national AIDS Control Program and different NGOs in educating about AIDs.

The first role was the study of AIDS patients, frequency in different social group of population. The next goal was the study of reasons of AIDS in different populations. Another aim was to educate people about prevention. The next role is the proper diagnosis of HIV in different private and government sector hospitals.

- Reproduction is the vital process by which living organisms produce off springs of their own kind.
- Reproduction is of two types
  (a) Asexual (b) Sexual Reproduction
- Asexual reproduction takes place without fusion of gamets i-e no genetic recombination.
- Sexual Reproduction takes place as a result of male and female gametic fusion i-e Genetic recombination occur.
- Asexual reproduction in Protist, Bacteria and Plants takes place by fision, budding, spores, vegetative propagation.
- Vegetative natural propagation means reproduction takes place by any part of plant except flower i-e by roots, stem, leaves and sucker.
- Artificial vegetative propagation takes place by cutting, grafting, clonning and apomixes.
- Sexual reproduction requires flower where stamen produce pollon grain which develop into male gametophyte i-e pollen tube, where as carpel contain ovule in its ovary.
- Ovule has embryo sac (female gametophyte) which produce ovums.
- Pollination is the transfer of pollen grains from anther to stigma of carpel.
- There are two types of pollination i-e self and cross pollination.
- After pollination pollen grain develop pollen tube carry male gamets to ovule where ovum is present.
- One of the male gamet fuse with ovum to produce 2N Zygote and 2N Secondary nucleus fuse with another male gamet to produce 3N Zygote. i-e Double fertilization.
- The ovule after fertilization develop into seed where as ovary develop into fruit.
- Seed is fertilized develop ovule contain dormaint embryo.
- The breaking of seed domaracy is called germination.
- Seed germinate into two ways i-e Epigeal and Hypogeal germination.
- Asexual reproduction in animal takes place by fission, budding, fragmentation (Regeneration).
- Sexual reproduction has three steps
  i) Gametogenesis ii) Mating iii) Fertilization.

- Spermetogenesis is the formation of sperm, where dogenesis is the formation of ovum.
- Male and female reproductive organs are
  - i) Gonades to produce gamets
  - ii) Ducts; gamets collecting tubes
  - iii) Genitals; gamets donating or receiving organs.
- Glands of male are prostrats, cowper's and seminal vesicle.
- Glands of female are ovaries.
- Fertilization is the fusion of male and female gametes form diploid zygote (2N)
- There are two types of fertilization i-e external and internal fertilization.
- Population planning is a policy to limit the growth in number of population.
- Sexually transmitted disease are those which are passed from one person to another through genital organ and genital fluid.

EXERCISE

A. MULTIPLE CHOICE QUESTIONS

Choose the correct answer:

i) The process which is essential for continuing and survival of species is

(a) Digestion (b) Respiration
(c)Reproduction (e)Excretion

ii) The type of reproduction which is necessary for evolution is

(a) Vegetative propagation (b) Fragmentation
(c) Sexual reproduction (d) clonning

iii) The unicellular structure, responsible for asexual reproduction without fusion is

(a) Pores (b) Spores
(c) Gametes (d) Pollen grains

iv) The example of stem which run horizontally on surface of soil to produce vegetatively

(a) Mint (b) Ginger
(c) Onion (d) Bryophyllum

v) Plant stem that arise from buds on the base of parent plants are

(a) Bulb (b) Rhizome
(c) Sucker (d) Runner

vi) The type of seed production without fusion of male and female gametes is
(a) Parthenocarpy (b) Apormixes
(c) Grafting (d) Scion

vii) The female gametophyte of anglosparmic plant is
(a) Embryo sec (b) Ovule
(c) Ovary (d) Carpel

viii) The 3N zygote is angiosperm develop into
(a) Seed coat (b) Cotyledon
(c) Embryo (d) Endosperm

ix) The male gonades in rabbit are
(a) Testis (b) Ovaries
(c) Scrotal sec (d) Vasdeferens

x) The female gametes are fertilized in the rear end of
(a) Oviduct (b) Follopin tube
(c) Ovaries (d) Both a and b

B. SHORT QUESTIONS:

i) Distinguish between asexual and sexual reproduction, Epigial and Hypogial Germination.
ii) Draw neat and labeled diagram of T.S of Angiospermic flower.
iii) How a new plant develops with an already growing plant?
iv) How leaves develop into new plants?
v) Draw neat and labelled diagram of Ovule.
vi) Draw neat and labelled diagram of male gametophyte of angiospermic plant?
vii) List out the male reproductive organs of rabbit with glands.
viii) What are STD's?
ix) Why population control is considered important for prosperous society?
x) Draw life cycle of Angiospermic plant.

C. EXTENSIVE RESPONSE QUESTIONS:

i) Describe natural asexual reproduction in plants.
ii) What is pollination? give adaptive characters of wind and insect pollinated flowers.
iii) Describe different types of asexual reproduction in animals.
iv) Describe the process of Spermetogenesis.
v) What is germination? Give the condition of germination also describe the methods of different germination.

Chapter 6

INHERITANCE

Major Concept

In this Unit you will learn:

- Introduction
- Chromosomes and Genes
- Law of Segregation
- Law of Independent Assortment
- Variation and Evolution

6.1 Introduction

It is a matter of common observation that the offspring of all organisms resembles their own parents. Man has long been aware that" like beget like" i.e. it is one of the characteristics of living things to reproduce their own kind. Frog always produces frogs, whereas of garden pea produces garden pea plants. These offspring's would show similarities to their parents. The characteristics of the offspring's to resemble their parents is called **heredity.** The branch of biology which deals with the study of heredity and Variations is called **genetics** whereas the process by which characters are transmitted from parents to off springs is called **inheritance.**

Living things when reproduce sexually, their offspring differ somewhat from their parents. They show resemblance with one another as well as with their parents but they are not their exact copies, even than the brothers and sisters of one parent, neither resembles exactly with one another nor with their parents. Similarly puppies of the same litter are not exactly alike. The same is true about plants, such differences are called **variations**.

Fig. 6.1 variable offspring of some parents.

Genes control inheritance of characters:

Life of every organism; every character of his structure; function and behavior, at all levels of biological organization is programmed and controlled by a set of instructions. These instructions are in the form of coded biological information called **genes**. This biological information to offspring is passed through egg and sperm (gametes)

which are the sex cells. You have also received your genes from your parents and they received their genes from their parents. Thus you and your brother and sisters share many genes of your parents and even of your grandparents. So the inherited characters are determined by genes which are transmitted from generation to generation. Therefore we can say that "Heredity is the way by which genes transmit characters from parents to offspring".

Fig. 6.2 Chromosome

As we know that each kind of organism has specific number of **chromosomes.** These numbers and shapes remain constant in all individual of a species generation after generation.

All human contains two sets of 23 chromosomes. One haploid set (n=23) is paternal in origin, which is contributed by sperm while the other haploid set (n=23) is maternal which comes from egg. The genes are located at chromosomes and inherited through chromosomes during sexual reproduction. The two chromosomes which are similar in their shape, size and position of centromeres present in a cell make one **homologous** pair of chromosome. These homologous sets of chromosomes provide the physical basis of heredity of an organism.

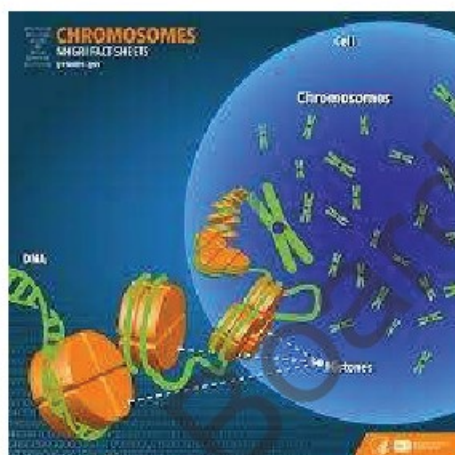
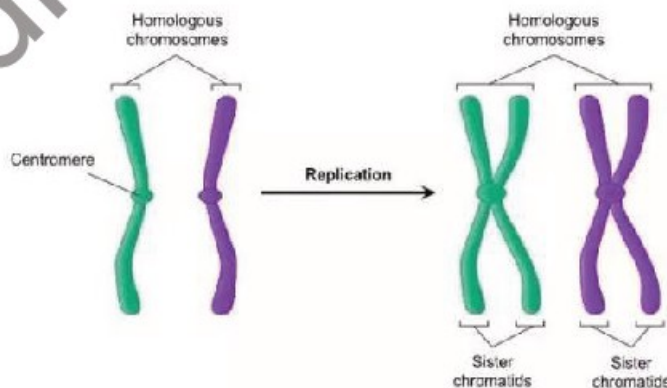



Fig. 6.3 homologous pairs of chromosomes of an organisms

6.2 CHROMSOMES AND GENES

As we know that the chromosomes are fixed in number and shape in the members of a species. These chromosomes contain many genes. Now the question arises what is the composition of chromosomes and genes?

Chemical Composition of chromosome:

The chemical material of chromosome is called **chromatin,** which is basically a **nucleo-protien** (Deoxyribo Nucleoprotien). It is composed of DNA (40%) and special protein i.e Histone (60%). DNA (Deoxyribo Nucleic Acid) is made up of billions of units called Deoxyribo Nucleotides. Each nucleotide is made up of deoxy ribose sugar ($C_5H_{10}O_4$), phosphoric acid (H_3PO_4) and Nitrogenous bases as shown below

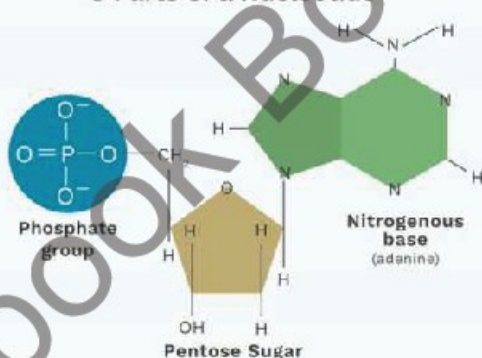



Fig. 6.4 Chemical structure of a nucleotide

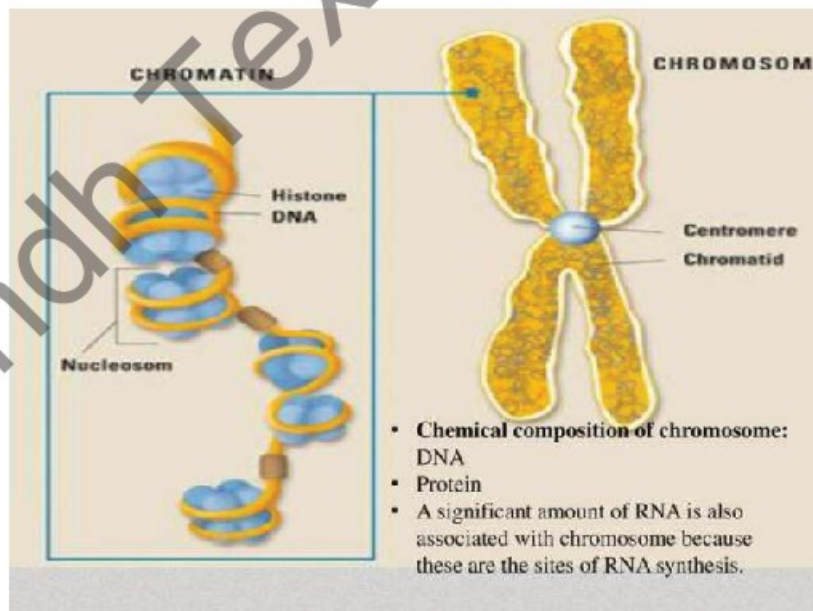
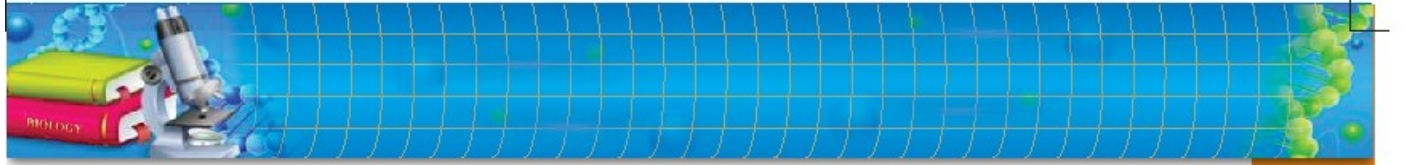



Fig. 6.5 Chemical Composition of

The DNA of a chromosome exists as one very long double stranded fiber, a duplex, which extends unbroken through the entire length of the chromosome. This long DNA is coiled to fit into a much smaller spaces.

If the strands of DNA from a single set of chromosome in nucleus were laid out in a straight line, it would be more than 7 feet (2 meter) long. This is too long to fit into a cell.

How coiling of this long DNA is coiled in very small chromosome and nucleus of cell?

If we gently disrupt a eukaryotic nucleus and examine the DNA with an electron microscope, we find that it is because the histone is positively charged while DNA is negatively charged. This beads of histone and DNA is called nucleosome, when the string of nucleosomes wraps up into high order coil called super coil. This super coiled chromomers form chromosome.

6.2.1 GENE A LOCALISED PART OF DNA

To understand the nature and composition of gene we must know about structure of DNA because gene is the localized part of DNA which has a coded information to synthesize a protein which works as enzyme.

Brief structure of DNA

The model of DNA was suggested by Watson and Crick in 1953. This model is based on X-Rays Photographs and chemical analysis of DNA. According to this model

- DNA is a double helical structure.
- Each helix is a polynucleotide chain which are twisted around each other.
- The outer part is called **Upright,** which are made up of deoxyribose sugar and phosphate. The inner part called **Rungs**, made up of paired nitrogenous bases.

- Both helix are complementary to each other which are held together by hydrogen bonds.
- The complementary helix have complementary base pairs i.e Adenine pairs with Thymine and Cytosine always pairs with Guanine.

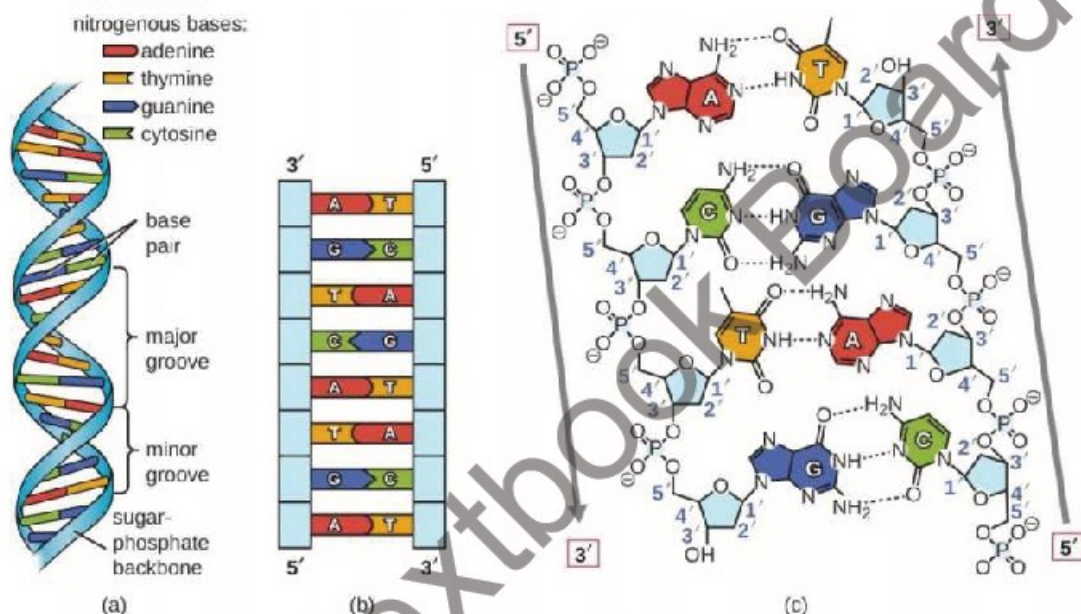



Fig. 6.6 Structure of DNA

Gene:

Gene is the small segment of DNA which has genetic information in the form of code to synthesize a protein. it is the basic unit of biological information. Each gene is located at specific position on chromosome, this position of gene on chromosome is called Gene **locus (loci)**. Each gene has a specific function e.g. a gene determines the height of plant; another gene determines the colour of their petals etc.

The coded information may change due to any reason which is called genetic variation caused by mutation. This genetic variation among off springs lead to tremendous variety in their traits. This variation in the genes of a trait give rise two or more than two alternative forms of a gene. These alternative forms of a gene called

alleles or **allomorph.** Some genes may have as many as 300 alleles. A diploid cell thus any two of these multiple allele while a haploid have one allele.

Gene is a Unit of inheritance which is copied and Inherited to the next Generation

The complementary arrangement of nucleotide is of great importance in DNA molecule. If the sequence of bases in one strand is known, the sequence of bases in the other strand will be automatically known due to specific base- pairing. This property of the two strands of double helix makes DNA a unique molecule best suited to store, copy and transfer genetic information from generation to generation.

DNA is able to make its exact copy itself in nucleus of cell before cell division. This process of duplication of DNA is called **replication** of DNA. Gametes are haploid cells, carry one copy of replicated DNA. This copy carry genes from parents to offspring through these gametes.

Fig. 6.7
Replication of DNA

The Watson and Crick model of DNA ideally proposed the mechanism of self replication. The hydrogen bond that hold together the double helix of DNA are broken up from one end to another end like a zip. The double helix gradually "unzip" along its length and each new nucleotide of the complementary nucleotide would be added to separate chains sequentially.

The Central Dogma of Protein Synthesis by Gene:

The term central dogma means a set of beliefs where a gene expresses by synthesizing a protein. This protein work as an enzyme, which carry down a chemical reaction to produce a metabolic product. This metabolic product either develops a character or lead to develop a character.

DNA is located in the nucleus of eukaryotic cell while most of the synthesis and metabolic reactions occur in cytoplasm under the instructions of DNA (genes). Therefore DNA requires some other molecules to carry its genetic information from nucleus to cytoplasm. These molecules are different type of **Ribo Nucleic Acids** or **RNAs**.

Genetic information flows in a cell from DNA to mRNA than to ribosome in cytoplasm, which is two step process for protein (enzyme) synthesis.

1. Transcription:

The step of protein synthesis where information which contained in a specific segment of DNA (gene) is copied in complimentary form (genetic codes) i.e. RNA. This RNA carry information of DNA sequences to ribosome from nucleus to cytoplasm called messenger RNA or **mRNA.** The process of copying DNA information to mRNA is called **Transcription**.

2. Translation:

In the second step two other types RNA: transfer RNA (tRNA) and ribosomal RNA (rRNA) translate the information of messenger RNA into the specific sequence of amino acids which help to synthesize the protein.

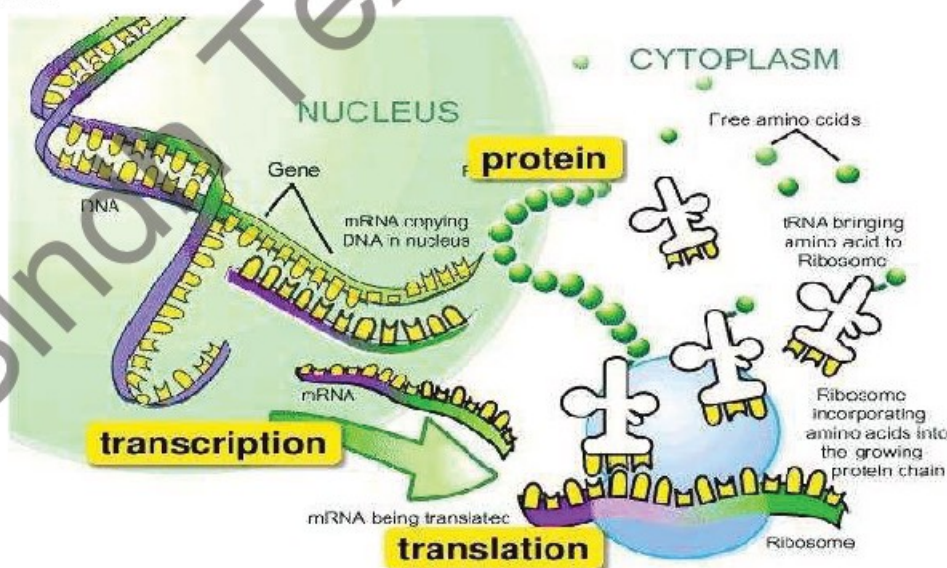



Fig. 6.8 Translation from gene to protein

6.3 MENDEL AND HIS LAWS OF INHERITANCE

Gregor John Mendel, an Austrian Monk carried out breeding experiment with garden pea (*Pisum sativum*). He explained the mechanism of heredity. He is known as **Father of Genetics**. He studied seven traits (characters) in pea plants one by one i.e. height, seed shape, pod shape, seed colour, flower colour, flower position, pod colour. He has chosen to study the contrasting pairs of these above traits because they were easily distinguishable like Tall and Dwarf. These varieties continued to produce offspring identical to their parents generation after generation, as long as they were self-pollinated such varieties are called true breeders and their offspring are pure-breeds.

Fig. 6.9 Gregor John Mendel

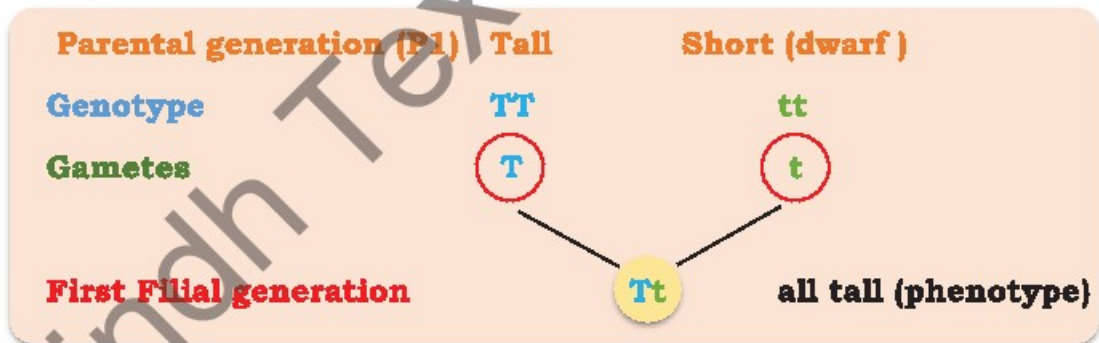
Pure-breed means that if an organism is self fertilized, the offspring always look exactly like parents e.g. if a parent pea plant is tall and have purple flowers perform self pollination to produce next generation, the offspring will always be tall and have purple flowers.

Fig. 6.10 Pea plant

Mendels study was based on these seven pairs of contrasting characters but considering the inheritance of single pair of contrasting characters at a time. He counted and recorded the parents and offspring of each of his cross. His keen interest in mathematics led him to the formulation of certain hypotheses which led him to present laws of Genetics.

6.3.1 Mendel's experiment and Law of Complete Dominance:

Mendel took gene as factor; he told that both parents donate one factor of a trait. If both the parents donate same factor of the trait, the organism is pure or **homozygous** for this trait like pure Tall i.e. TT, same as the pure short (dwarf) i.e. tt is also **homozygous**. On the other hand if both parents donate different factors (allele) of a trait, the organism is **hybrid or heterozygous** for the trait i.e. Tt for tall.

In one of his experiments, he took pure tall stem and short stem varieties and crossed them. All the seeds were collected and allowed to grow. He founded that all the plants were of tall stem, no plant with intermediate stem were found to grow in this generation. He repeated his experiment on pea plants with different traits having contrasting characters, found same result than he presented the **law of dominance**. According to this law, when a pair of contrasting characters (heterozygous) is brought together in a cross, only one factor will express in the offspring while other will be masked. It means that in heterozygous condition one factor is completely dominant over other.

From above experiment some terms came into light which are commonly used in genetical studies.

6.3.2 Common terms used in Genetics:

Dominant:

The factor (gene) which express and masks the expression of other factor in heterozygous condition is said to be Dominant factor. Mendel represent it with capital letter like T for tall.

Recessive:

The factor which is unable to express or masked in heterozygous condition is said to be recessive. It represents by small letter of same alphabet like t for small (dwarf).

Phenotype:

It is the physical appearance of the trait on the basis of inherited genes like tall, dwarf, round seed, wrinkled seed etc.

Genotype:

The genetic makeup or genic constitution of a trait like TT, Tt, tt etc.

Homozygous:

An individual having same factors (allele) of a trait called **homozygous**. For example, TT (factor for tallness).

Heterozygous:

An individual having different factors of a trait called **heterozygous**. For example, Tt (factors of tallness and dwarfness both).

Parental generation (P1):

The original true breeding organisms were called **parental generation** or **P1** by Mendel.

Filial one generation or F1:

the offspring of true breeding organism were called **First Filial Generation** or **F1**.

Second Filial generation or F2:

The offspring of filial one generation produced by crossing self fertilization were called **Second Filial generation** or **F2**.

6.4 MENDEL'S LAW OF SEGREGATION OR LAW OF PURITY OF GAMETES

Mendel when crossed pure tall and dwarf plant and got all tall plant in F1 generation but unlike the P1 tall, these plants of F1 generation were heterozygous. Mendel did not stop his experiments here. He planted all the seeds of F1 generation and allowed them to self pollinate. He observed that in the next generation (F2), both the parental types, i,e. tall and dwarf stem varieties were produced. When he counted these, he found that in F2 generation, the two types of the individuals were present in a ratio of 3:1 tall and dwarf respectively. Mendel perceived from these results that when the plants of F1 generation form their gametes, the factors (allele) separate or segregate again in such a way that only one of the two alleles enters each gamete. On the basis of these observation he presented the "Law of segregation" this is also called **law of purity of gametes**. This law states that in an organism, the factors (genes) exist in pairs but during gametes formation these factors segregate cleanly from each other, so each gamete has only one factor of a trait.

Fig. 6.12 Alleles separation during gamete formation

6.5 MENDEL'S LAW OF INDEPENDENT ASSORTMENT:

Mendel's experiments on garden peas were not limited to a single trait as explained in law of segregation, but sometimes involved two or even more characters. He crossed between two individuals (pea plant) differing in two traits which he called Dihybrid –Cross and the ratio obtained in F2 generation called Dihybrid-ratio. The results achieved as a consequence of dihybrid-cross is known as Inheritance of two traits.

When Mendel crossed yellow cotyledon and rounded seed containing plant with green cotyledon and wrinkled seed containing plant. The F1 generation had all plants with yellow cotyledon and

round seeds. This proved Mendel previous findings that allele for round seed is dominant over wrinkled while yellow cotyledon over green.

Mendel self fertilized the F1 generation, expecting either of the two following possibilities:

(a) If the genes for round seed and yellow colour are inseparable (dependent on each other), as well as those for wrinkled shape and green colour, then in F2 generation ¾ of the seeds will be round and yellow and ¼ will be wrinkled seed and green.

(b) If the genes for seed shape and cotyledon colour are separable (independent) and distributed to the gametes independent to each other, then in F2 generation some plants produce round seeds with green cotyledon and some have wrinkled seeds with yellow cotyledon will also be expected along with parental combinations.

Mendel actually obtained four different kinds of phenotype in F2 generation. Out of a total 556 seeds, he obtained four different phenotypes i.e

Round and Yellow seeds =315, Wrinkled and Yellow seeds =101
Round and Green seeds =108 Wrinkled and Green seeds =32

Genotypes for round and yellow seeds RRYY, RRYy, RrYY, RrYy
Genotypes for round and green seeds RRyy, Rryy.
Genotypes for wrinkled and yellow seeds rrYY, rrYy.
Genotypes for wrinkled and green seeds rryy.

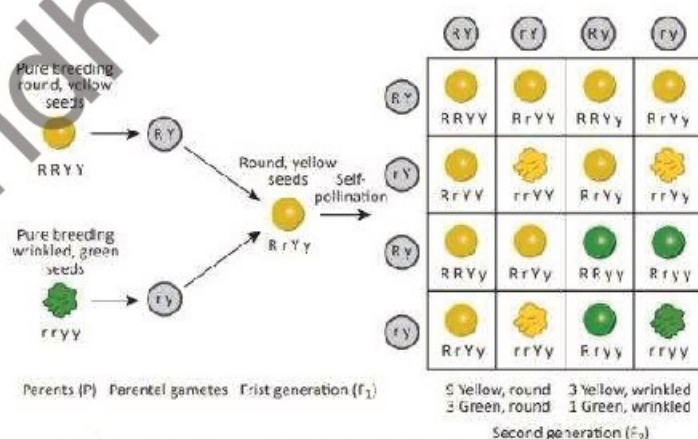



Fig. 6.13 Expected ratio in dihybrid cross.

These numbers are in a ratio of about 9:3:3:1 for the four phenotype it showed that the genes for seed colour and shape are independent in their inheritance. They do not necessarily stay together in the combination in which they occurred in parents.

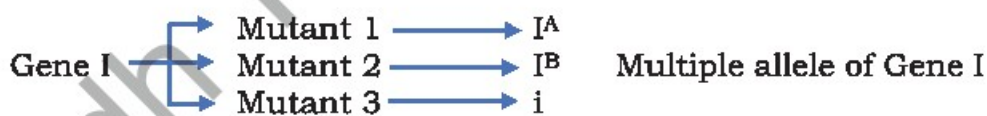
This observation led to the formation of **Mendel's law of Independent assortment**. It is stated that the genes of assorted traits are independent in their inheritance

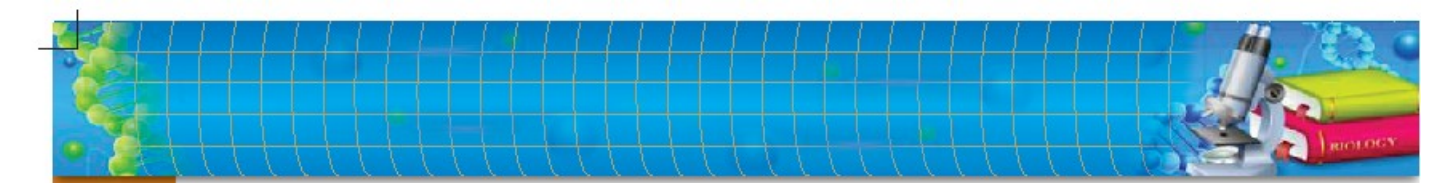
OR

"Members of one pair of genes separate from each other during gametes formation".

Multiple Allele (Blood Groups in human as an example)

According to Mendel's finding that each trait has two alternative forms (allele). Later it was found that some trait has more than two and more alternative forms. These traits are called **Multiple Allelic Trait** or **Multiple alleles**. ABO blood group system in human population was the first discovered multiple allelic trait. Karl Landsteiner in 1901 discovered ABO blood group system. There are four phenotypes due to presence or absence of two specific antigen on the surface of RBC.

The genetic basis of ABO system was explained by Bernstein in 1925. This system is controlled by a polymeric gene I on chromosome 9, contain three alleles i.e. $I,^A I,^B$ and i.

Blood Group	Genotype	Phenotype & Antigen	
Group A	$I^A I^A$ $I^A i$	A-Homozygous A-Heterozygous	A
Group B	$I^B I^B$ $I^B i$	B-Homozygous B-Hetrozygous	B
Group AB	$I^A I^B$	AB-Heterozygous	AB
Group O	i i	O-homozygous	NO

R^h blood type (R= Rhesus):

This protein was first time observed in rhesus monkey the another mendalian gene found in human. This gene produce a protein which is found on the surface of R.B.C as well. This trait has 2 allele a dominant R^h and r^h recessive. The Rh protein produce R^h protein therefore person called R^h+ve where as r^h gene is unable to produce R^h protein so the person called R^h-ve person will be r^hr^h.

Role of antibodies for AB and R^h in blood transfusion:

It is already known that the chemicals cells or organs of an organism can work as antigen to other organism. When these antigens enter in the body of other organism. This organism produce defense protein against this antigens to protect itself. These proteins are called antibodies.

The blood group alleles (I^A, I^B, i) starts their expression at embryonic stage and keep expressing till death. The person also produce anti-A, anti-B antibodies during first few months after birth. The person of A-blood group produce anti-B antibodies while person of B-blood group produce both anti-A and anti-B antibody while person with AB blood group do not produce any of the while person with AB blood serum containing antibodies called antibody. The blood serum containing antibodies called antiserum.

The person of A blood group which contain anti-B antibodies if given blood of B-group. The R.B.C of this B-blood group will work as antigen in the person of A-blood group it anti-B antibodies will work against the donor R.B.Cs of B-blood group and clumped cells called agglutination. Which lead to serious problem, this clumped cells can not pass through fine capillaries. Therefore during transfusion of blood the people must be careful about blood group.

Blood group	Blood group recipient	Reason
A B AB	A and AB B and AB AB only	Recipient donot have antibodies A. Recipient donot have antibodies B Recipient neither have antibody A or antibody B
O	O,A,B,AB	• Blood group have antibody A and antibody so it can receive only O blood group. • O blood can be donated to A, B and AB because donor's antibodies are quickly absorbed by other. Tissue or diluted in recipient blood. Therefore O blood is called universal donor

On the other hand side the R^h factor has different phenomena: unlike the naturally occurring anti-A and anti-B antibodies of ABO system, anti-R^h antibodies do not produce automatically. The production of anti-R^h antibodies require stimulus which is R^h human protein itself. It works as antigen. If an R^h-ve person receive R^h protein (antigen) through wrong R^h+ve blood transfusion, he will begin to produce anti-R^h antibodies against R^h antigens. R^h–ve blood person does not contain any R^h protein (antigen) can be transferred to R^h+ve person (recipient).

Co-Dominance:

According to Mendel's law of dominance only one factor expresses in heterozygous condition but it was also found that some trait has alleles that are both expressed in a heterozygous condition independently. This phenomenon of inheritance where both alleles are dominant and expressed equally called Co-Dominant e.g. AB blood group, where both alleles I^A and I^B express and produce antigen A and B both.

Incomplete Dominance:

Carl Correns in 1899 crossed a pure breed red flowered Japanese 4 O' clock plant with pure breed white flowered. He found pink flowered plant in F1, these results were against the Law of dominance. This new phenotype was intermediate between those parents. When Correns self-pollinated F1 pink flowered plant, the F2 showed all three phenotypes of flowers in the ratio of 1 red; 2 pink: 1 white. Red and white are homozygous for their respective alleles. It was also found that when alleles for red and white were present together (heterozygous) in the same plant, neither of them masked the effect of other, therefore expression of both genes blended to produce new phenotype.

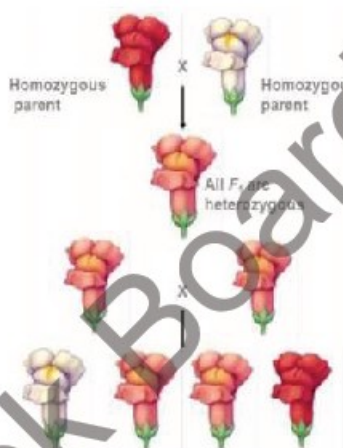



Fig. 6.13. 4 O'clock plant

This phenomenon of inheritance where both alleles of a trait express in heterozygous condition and their expression get blended to produce new phenotype called **incomplete dominance** or **partial dominance**.

6.6 VARIATIONS AND EVOLUTION

From previous discussion we have learnt that living things exist in great variety. They have many features in common. For instance there are fundamental similarities in their chemical structure. Not only in chemistry, there exist similarities in morphology also such as rats with mice, turtle with tortoise, frog with toad etc.

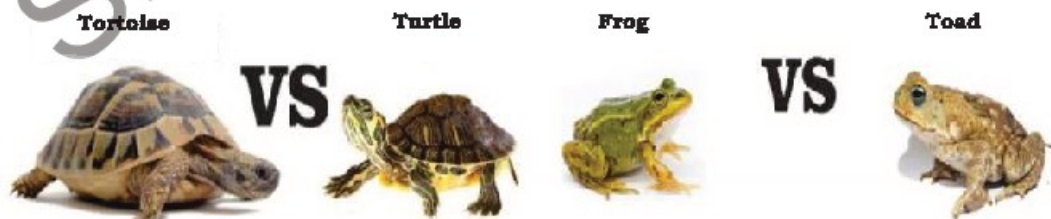



Fig. 6.14 Similarities in animals

Similarities discussed above and yet numerous other similarities suggest that species are more closely interrelated in some ways, some species are more closely interrelated than the others. The great variety of forms leads to many questions such as: How living things vary from each other? Have they always been like this? Did the great variety of life forms appear with time?

To account for the answers of these question, first of all we will see the variation and its causes:

6.6.1 Variations and their causes:

The differences in characters such as height, colour, etc. among individuals of same species are called **variations**. Variations may be caused either by the effect of environment or by the changes in the genetic material.

a) Environmental variation:

Variation caused by environmental factors among the members of same species, it is not inherited to the offspring e.g development of muscles in athletes, loss of some body parts due to accident or diseases etc.

Fig. 6.15 Muscles development

b) Heritable variation:

The variation caused due to changes in genetic material called genetic or **heritable variation**. This type of variation is considered as raw material for evolution.

On the basis of effects there are other two types of variation

c) Continuous variation:

These variations refers to small differences in characters of the members of a species i.e. Height, Skin colour, Intelligence, Eye colour etc such variations are neither purely genetical nor purely

environmental. They appear to be the combination of both factors.

Fig. 6.16 Variation in skin colour and height

d) Discontinuous variation:

These are sudden and sharp differences among the members of same species. They are heritable as they are purely caused by genetic material. Blood groups, six fingers in hand or foot, tongue rolling etc are common examples in man.

Fig. 6.17 Discontinuous Variation

6.6.2 Causes of variations

some important causes of variations are as follows

i) Mutation:

It has been a common observation that some strikingly different characters than the others e.g. some person has six fingers in hands or feet. This phenomenon of producing sudden changes is called **mutation**. It can be defined as the sudden changes In the genetic material (genome) of an organism. It is the major source of heritable variation among the organisms which is considered as the starting point of new species.

ii) Crossing over:

It is the process of mutual exchange of segments of chromatids between non-sister chromatids of homologous pair of chromosome. It occurs during prophase of 1st meiotic division. Due to crossing over maternal and paternal alleles are mixed and segregated. So the indefinite combinations of alleles are made. Due to this crossing over and segregation, offspring of same parents become variable.

iii) Environment:

Number of environmental factors affect the body cells to cause variations e.g. the changes in the pigmentation of skin due to extent of exposure to sun light or the development of muscles due to exercise etc.

iv) Independent assortment of chromosome:

During metaphase of first meiotic division homologous chromosome come together in the form of pairs and subsequently segregate during anaphase I into the daughter cells independently. This produces a wide variety of different gametes.

v) Fertilization:

The set of alleles carried by chromosomes of each gametes is unique and always differ from each other. There are number of male gametes available to fertilize a single female gametes. Thus different combination of characters in an individual are possible as a result of fertilization.

This all painstaking scientific work of biologist leads to the idea of evolution especially organic evolution. Evolution is the process where descends become better than ancestors, while the organic evolution explains that present day living things are modified from simple ancestral forms during the course of time through a gradual and continual process of modification.

Theories of organic evolution not only explain how living things have become so varied, it also explains their basic similarities as well.

Several theories have been proposed to explain the mechanism of evolution, we are going to discuss some of them here.

6.6.3 Theory of Natural Selection or Darwanism:

Charles Darwin (1809-1882) was an Englishman. He studied different plants and animals, collected new specimens and categorized them. In the year 1859, he published a book **"Origin Of Species"** where he proposed the theory of Natural Selection, in which he presented simple evidences in favour of evolution and proposed the mechanism of origin of species.

The main points of the Darwin's theory are as follows:

i) **Over Production**: living organisms reproduce rapidly so that the number of their offspring could increase rapidly.

ii) **Struggle for Existence**: Due to the limited available resources of food, shelter, etc. the offspring of species compete not only with each other but also with the members of different species to share these resources. In this struggle a large number of

individuals of each species are eliminated. As a result the population remains stable.

iii) Heritable Variation: Individuals of a species differ from each other in their ability to obtain resources, withstand environmental extremes, etc. These differences in characters are called **minor variations**. Darwin concluded that survival in struggle for existence is not random but depends upon in part on the heredity constitution of the surviving individuals. Those individuals whose inherited characters fit them best to their environment would survive and produce more offspring than less fit individuals who will vanish.

iv) Natural selection: Nature selects the fittest individuals to survive and reproduce. As a consequences, the favourable variations are preserved through their inheritance to new young ones.

Over millions of years of variations, natural selection and inheritance might have led to the accumulation within the species a number of characters with survival value. As a result, a species may slowly changes to a better new species. Darwin was very much convinced by Artificial selection.

Fig. 6.18 Darwins finches as a result of natural selection

Number of evidences are reported in support of evolution from comparative anatomy, homologous organs, analogous organs, vestigial organs and fossils.

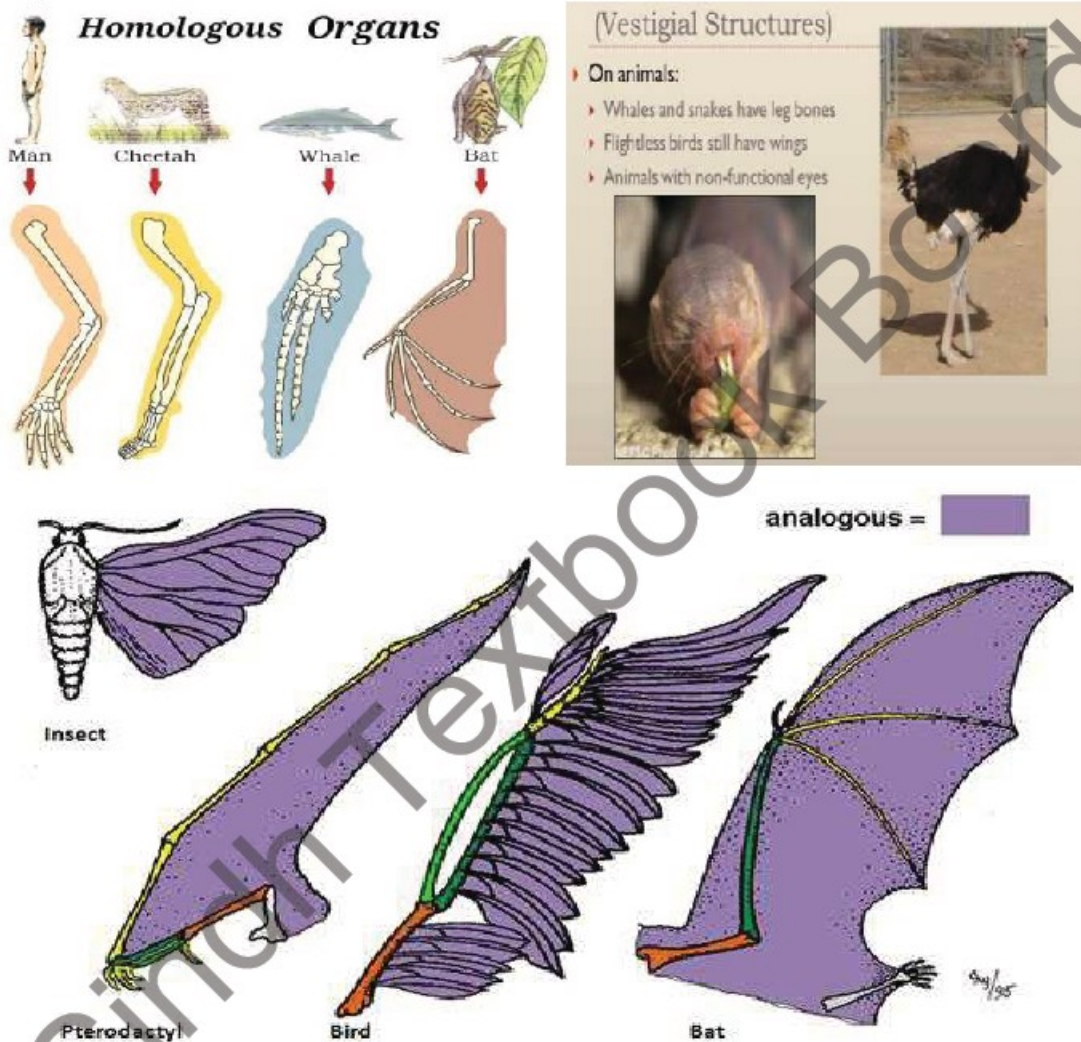



Fig. 6.19 Homologous, Analogous and Vestigial organs

6.6.4 Evidences from Artificial Selection:

Artificial selection is the cross breeding of domestic animals and plants to produce specific desirable features. Various breeds of dogs, pigeons, sheep, horse, cattle, cow, buffalo, hen etc. among the animals,

have been developed through artificial selection. Darwin convinced biologists that the process of artificial selection could produce so many changes in a species in relatively short period of time, then natural selection should be capable of considerable modification of species over thousands of generations

A

B

ARAB: 14.2HH
SHETLAND PONY: 10.0HH
FELL PONY: 14.0HH
SHIRE HORSE: 17.2HH
EXMOOR PONY: 12.2HH
NEW FOREST PONY: 13.1HH
SUFFOLK PUNCH: 16.2HH
MUSTANG: 14.2HH
THOROUGHBRED: 16.0HH

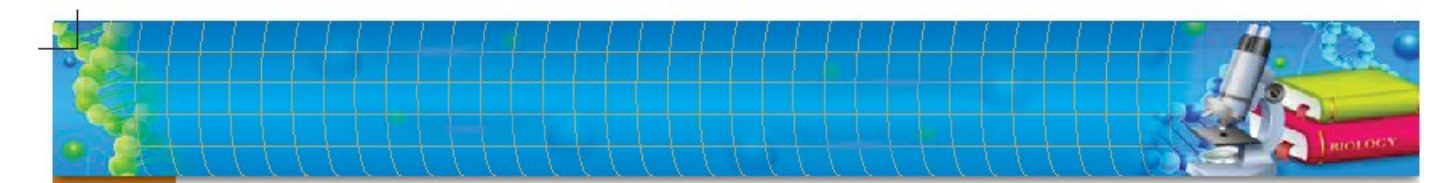



Fig 6.20 Different breeds of (A) Goats, (B) Horses by artifical selection

SUMMARY

- The branch of biology which deals with the study of heredity and variations is called **genetics**
- The process by which characters are transmitted from parents to offsprings is called **inheritance**.
- Living things when reproduce sexually their offspring differ somewhat from their parents, such differences are called **variations**.
- Heredity is the way by which genes transmit characters from parents to offspring.
- All human contains two sets of 23 chromosomes.
- Haploid set (n=23) is paternal in origin, which is contributed by sperm while the other haploid set (n=23) is maternal which comes from egg.
- The genes are located at chromosomes and inherited through chromosomes during sexual reproduction.
- Two chromosomes which are similar in their shape, size and position of centromeres present in a cell make one **homologous** pair of chromosome.
- The chemical material of chromosome is called **chromatin**.
- Deoxyribo nucleoprotein is composed of DNA and special protein i.e Histone. DNA(Deoxyribo Nucleic Acid) (H_3PO_4)
- Eukaryotic chromosome are composed of **chromatin**, a complex of DNA and protein i.e. 40% and 60% respectively.
- DNA is a double helical structure.
- Each helix is a polynucleotide chain which are twisted around each other.
- Both helix are complementary to each other which are held together by hydrogen bonds.
- Gene is the small segment of DNA which has genetic information in the form of code to synthesize a protein.
- The process of duplication of DNA is called **replcation** of DNA.

- A gene expresses by synthesizing a protein. This protein works=] as an enzyme, which carry down a chemical reaction to produce a metabolic product.
- Genetic information flows in a cell from DNA to mRNA than to ribosome in cytoplasm, which is two step process for protein (enzyme) synthesis.
- Transcription: DNA (gene) is copied in complimentary form. The process of copying DNA Information to mRNA is called **Transcription**.
- Translation tRNA and rRNA translate the information of mRNA into the specific sequence of amino acids.
- Gregor John Mendel is known as **Father of Genetics,** He studied seven traits (characters) in pea plants one by one.
- Pure-breed means that if an organism is self fertilized, the offspring always look exactly like parents
- Mendel took gene as a factor; if both the parents donate same factor of the trait, the organism is pure or Homozygous for this trait like pure Tall.
- If both parents donate different factors (allele) of a trait, the organism is hybrid or Heterozygous for the trait
- The factor (gene) which express and masks the expression of other factor in heterozygous condition is said to be Dominant factor.
- The factor which is unable to express or masked in heterozygous condition is said to be recessive.
- **Phenotype** is the physical appearance of the trait on the basis of inherited genes like tall.
- **Genotype** genetic makeup or genic constitution of a trait like TT, Tt
- In an organism, the factors (genes) exist in pairs but during gametes formation these factors segregate cleanly from each other, so each gamete has only one factor of a trait.
- Some trait has more than two and more alternative forms. These traits are called multiple allelic trait or **multiple alleles**.
- The phenomenon of inheritance where both alleles are dominant and expressed equally called **Co-dominance**.

- The phenomenon of inheritance where both alleles of a trait expressed in heterozygous condition and their expression get blended to produce new phenotype called **incomplete Dominance** or **Partial Dominance**.
- The differences in characters such as height, colour, etc. among individuals of same species are called Variations. Variation may be caused either by the effect of environment or by the changes in the genetic material.

A. MULTIPLE CHOICE QUESTIONS

Choose the correct answer:

i) Branch of biology deals with the study of heredity and variation is called:
(a) Inheritance (b) Heredity
(c) Genetics (d) Evolution

ii) The way by which gene transmits characters from parents to offspring is
(a) Genetics (b) Inheritance
(c) Heredity (d) Allele

iii) Two similar chromosomes in a cell which are similar in shape, size and position of centromere called
(a) Chromatids (b) Arms
(c) Homologous (d) Homology

iv) The chemical material of a chromosome is called
(a) Chromatin (b) Chromeres
(c) Chromonema (d) Chromatid

v) The outer part of DNA helix made up of sugar and phosphate is called
(a) Nucleoprotein (b) upright
(c) Rungs (d) Phosphoester

vi) The small segment of DNA which has information to code one protein is called
(a) Nucleotide (b) Polynucleotide
(c) Gene (d) Exon

vii) The exact duplication of DNA is called
(a) Duplication (b) Replication
(c) Transcription (d) Translation

viii) If both the parents donate same factors of a character is called
(a) Homologous (b) Heterologous
(c) Homozygous (d) Heterozygous

ix) The Genetic constitution of a trait is called
(a) Genotype (b) Phenotype
(c) Genome (d) Phenyl

B. SHORT QUESTIONS:

i) What is gene and how it works?

ii) Define following terms
(a) Homologous Chromosome (b)Heterologous Chromosome
(c) Dominant allele (d) Allele
(e) Recessive allele (f) Homozygous
(g) Heterozygous

iii) Which of the phenomena of inheritance is there where both factor express in heterozygous condition.

iv) List out the factors which are involved in theory of natural selection.

v) Relate artificial selection with natural selection.

C. EXTENSIVE RESPONSE QUESTIONS:

i) Describe the Waston and Crick model of DNA.

ii) How gene express describe in detail.

iii) State and explain the law of segregation of Mendel's.

iv) Explain the inheritance of dihybrid cross by law.

v) Explain the Darwin of theory of natural selection.

Chapter 7

MAN AND HIS ENVIRONMENT

Major Concept

In this Unit you will learn:

- The Ecosystem: Levels of Ecological Organization; Components
- Flow of materials and energy in the ecosystem
- Biogeochemical Cycles (Carbon Cycle & Nitrogen Cycle)
- Interactions in the Ecosystem (Competition; Predation; Symbiosis)
- Ecosystem Balance and Human impact on environment (Population growth)
- Urbanization, Industrialization, Deforestation)
- Pollution, its Consequences and Control
- Conservation of Nature

7.1 INTRODUCTION

No living organism exists in isolation. Each and every living organism is surrounded by material and energy, which constitute its environment and from where it must derive its needs. Thus for its survival plants, animals and microbes etc. require from its environment a supply of energy, supply of materials and removal of waste products. For these basic requirements each living organism has to depend open and also interact with different nonliving (abiotic) and living (biotic) component of the environment. The abiotic components include inorganic elements such as water, carbon dioxide, oxygen, nitrates, carbonates etc. Organic compounds like carbohydrates, proteins, lipids etc. and physical features such as solar energy, wind, temperature, rainfall, soil etc. The biotic component consists of bacteria, fungi, plants, animals etc. The Scientific study of environment, ecology, evolution and global change with in a combined form called **environmental biology**. It examine the ways where organism, species and communities influence and impacted by natural and human altered ecosystem.

7.2 LEVELS OF ECOLOGICAL ORGANIZATION

Life is supported on earth within a thin envelop of air, water and soil. No life exists beyond the earth's atmosphere or deep beneath its upper crust. Thus life sustaining envelope of earth is called **biosphere**.

In ecology, the level of organization ranged from organism to biosphere. The area where an organism lives is called its habitat. It may be on land, in water or in the air.

Fig.7.1 Biosphere

For example

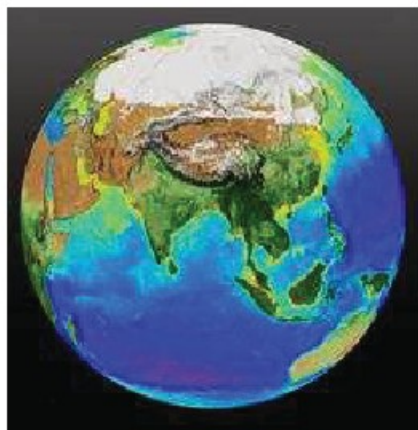
Habitat of frog is a pond. The group of organism belong to the same species lives in a particular area is called **population.** The group

of populations that lives in a particular area or habitat and interact with each other is called **community**.

Fig. 7.2 Population of Deer Family

Fig. 7.3 Showing Some Members of a Community

For example-A fresh water pond includes a population of *Hydrilla*, a population of frogs, insects, worms, rohu and many other kinds of animals. Members of community interact with each other as well as with their nonliving environment. During this interaction energy is also transferred from one to another level. So the area where these all interactions occur called **Ecosystem**.

The term 'ecosystem' was first proposed by Tansley in 1935, where 'Eco' means the environment (house) and 'System' implies an interacting area. An ecosystem is composed of organism interacting each other and with the abiotic environment, as well as flow of energy occurs in a given area. Thus an ecosystem may be as small as a dead trunk tree, a puddle or as large as an ocean or forest. The largest possible major community comprised of all living organisms on the earth is called **Biosphere.** All ecosystems on earth combine and constitute the giant ecosystem, the biosphere. The biosphere may be divided into sub-levels, biomes. Any bio-geographical region recognized by specific vegetation or climate called **Biome**.

7.2.1 Components of ecosystem

We have already studied in lower classes that ecosystem is comprised of two main components.

1. Abiotic Components
2. Biotic Components

1. Abiotic component

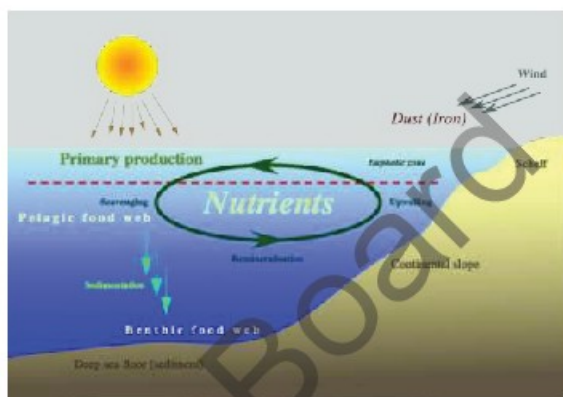
Abiotic components of an ecosystem are the physical aspects of its surrounding which influence upon the biotic components. They may control their distribution, reproduction, feeding, growth and metabolism. Many abiotic components affect an ecosystem but most important are light, temperature, water, soil and air. All these work in interacting manner.

Fig. 7.4 Abiotic component

Light

It is the most vital factor, without it life cannot exist. It is a source of energy for every ecosystem. Plants convert this light energy into chemical energy by the process of photosynthesis. This chemical energy is stored in the form of food which is needed by every living thing. Distribution of plants and animals is affected by the type, intensity and exposure time of light. A small amount of this light is utilized in photosynthesis whereas the rest of it maintains the temperature of earth and atmosphere. Light is also necessary for vision and for the start of certain biological processes e.g. flowering of certain plant, making vitamin D in human beings and migration of many animals.

Temperature

Another important abiotic factor affecting an ecosystem is temperature. It is low at high altitudes and high latitudes, the flora and fauna changes accordingly. Temperature changes during day and night, also varies from season to season. Many birds and few mammals migrate or hibernate in winter. Enzyme activities of metabolic reactions are also altered with the changes in temperature. Most forms of life cannot survive this extreme temperature.

Water

All the living things need water. It is the major part of protoplasm. It acts as the solvent for most of the compounds, raw material of photosynthesis, inorganic substances enter in plants with water in dissolved form.

The amount of water on land is controlled by rainfall and snowfall. The vegetation on earth is depended on the rate of rainfall. It means it also controls the distribution of plants and animals on land. For example forest grows in the area which receives abundant rainfall whereas low rainfall in the area with extreme temperature develops desert conditions.

Soil

The upper layer of earth crust consists of particles of varying size and decomposed organic material by microorganism called **soil**. The decomposed dead animals and plants called humus. Humus enriches the soil and increases its water and air holding capacity. Plants are anchored in soil and depend on it for their growth by absorbing water and in organic substances. The type of soil and its fertility determines the flora hence fauna of an ecosystem.

Air

Air is the gaseous envelope which surrounds the earth. It plays an important role in smooth running of the ecosystem. Air is the mixture of N_2, O_2, CO_2 and H_2O vapours mainly. Nitrogen is an essential constituent of protein. Oxygen is vital for respiration of all living organisms whereas CO_2 is the main requirement of photosynthesis to produce primary product i.e. carbohydrates.

Humidity is the quantity of H_2O vapours in the air controls the rate of evaporation of H_2O and transpiration in plants. The composition of air and its velocity control other abiotic factors of environment which indirectly affect the plant and animal life as well as the ecosystem as whole.

2. Biotic components of an ecosystem

The living organisms which interact in an ecosystem are called biotic component. These living components include producers, consumers of all types and decomposers.

a. Producers

All living organisms which can trap and convert energy into food molecules called producers because they produce food for themselves and other organisms of ecosystem. They are primary source of energy for other organisms. Hence all members of community depend, directly or indirectly on the producers for their food and energy. These are photosynthetic bacteria, algae and plants.

b. Consumers

Animals and all other organisms which cannot make their own food are called consumers. They get energy and food from producers directly or indirectly.

On the basis of feeding level (trophic) mainly consumers are of three types.

i. Primary consumers

The consumers which directly feed on producers i.e. get energy and food directly from producers called primary consumers e.g. a grasshopper or caterpillar feeding on leaves of plants are primary consumers. They are herbivores.

ii. Secondary consumers

The type of consumers which feed on primary consumers e.g. gets energy and food from primary consumers called secondary consumers. For example a bird is a secondary consumer gets its energy and food when it eats grasshopper or caterpillar. They are carnivores.

iii. Tertiary consumers

The organism which eats the secondary consumers to get energy and food called tertiary consumers and they are carnivores e.g. an eagle which eat the small bird, which has already eaten grasshopper.

Leaves —Eats→ Grasshopper —Eats→ Sparrow —Eats→ Eagle

(Producer) (Primary Consumer) (Secondary Consumer) (Tertiary Consumer)

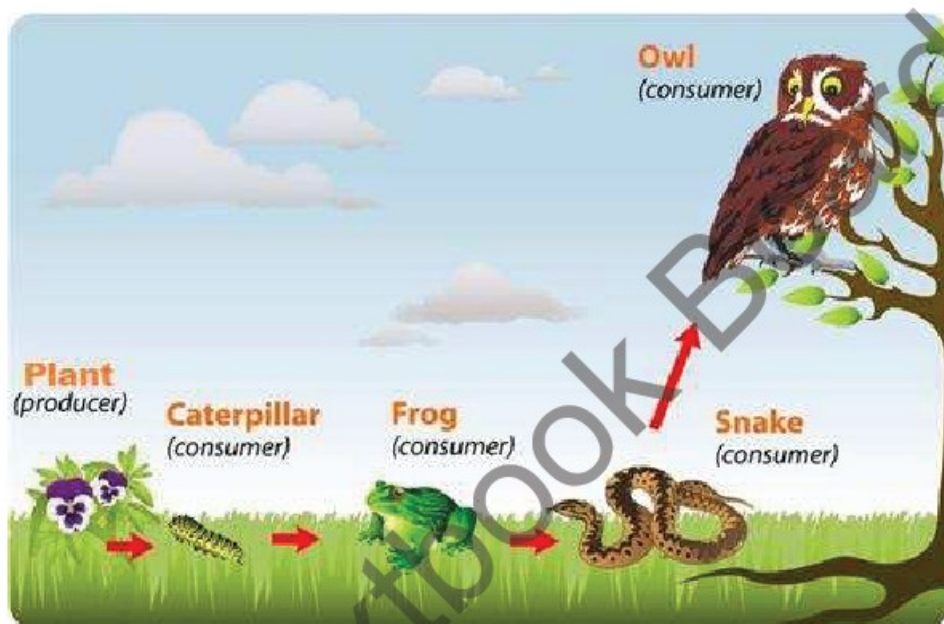
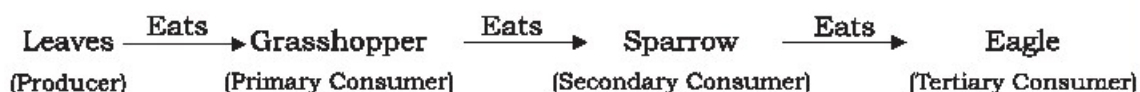



Fig. 7.5 Tertiary consumers

c. Decomposers

Microorganisms which break down complex food molecules of dead organisms called Decomposers. They are generally bacteria and fungi. They recycle the nutrients because they returned it by decomposing and converting complex organic molecules into simple inorganic molecules.

7.3 ENERGY FLOW IN AN ECOSYSTEM AS A NON-CYCLIC PROCESS

All the organisms in an ecosystem need energy to carry out their life activities to stay alive. Its primary source is solar energy coming through sun in the form of sunlight.

The energy of sun is trapped by producers (phototrophs) and converted into energy rich organic food molecules. Part of this energy is

transferred to primary consumers when they eat producers. Primary consumers when eaten up transfer this energy to secondary consumers which in turn form the meal of tertiary consumers. Hence the energy is transferred to next level, the tertiary consumers. These steps of transfer of energy rich food are called trophic levels, and this series of energy transfer from one trophic level to another by eating or being eaten up is called a food chain, represented by using arrows.

At each trophic level not all but a small amount of energy is transferred to the next level where it is stored as plant material or animal flesh. More than half of the energy is lost as heat. A significant quantity is consumed at each level by the organism itself in carrying out its own functions like movement, respiration, reproduction etc. It is therefore, all the energy at each level never reaches the next level, only 10% of energy at each level transferred to next level. This reduction is transfer of energy at various levels in an ecosystem is expressed in the form of a pyramid called pyramid of energy.

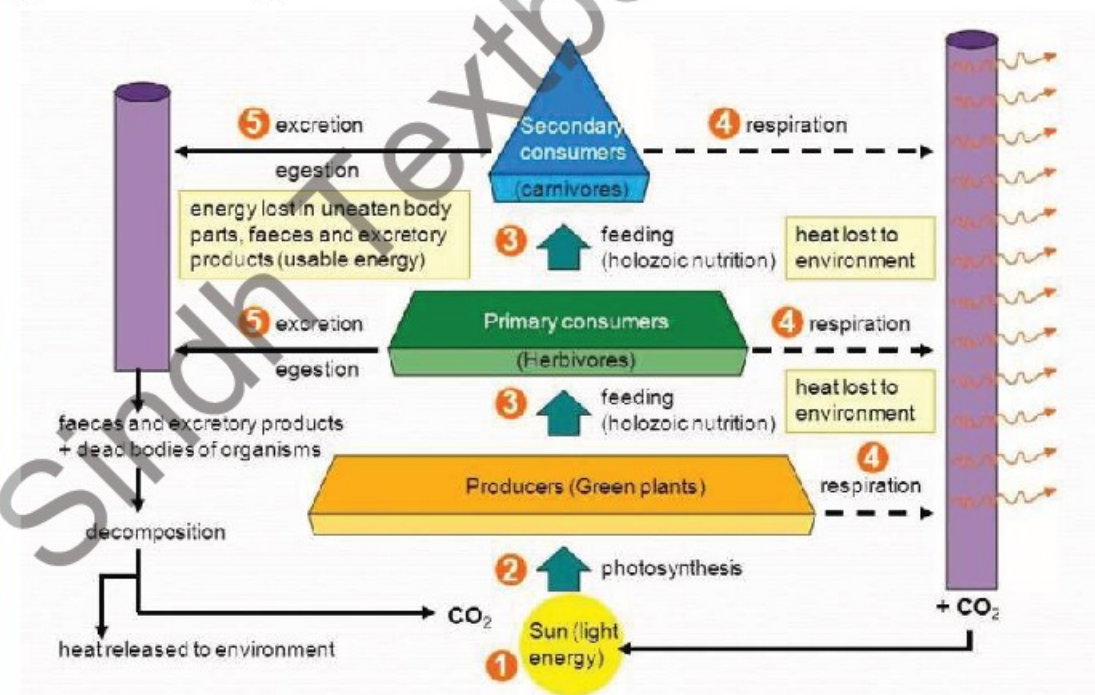



Fig. 7.6 Non- Cyclic energy flow in an eco system

7.4 FLOW OF MATERIAL IN ECOSYSTEM AS CYCLIC PROCESS

In an ecosystem organic and inorganic materials flow in two ways, which are cyclic and interlinked with each other in some manner. These are;

- **i.** Food chain and Food web
- **ii.** Biogeochemical cycle

i. Food chain and food web

In ecosystem, the flow of food material progresses through food chain in which one step follows another like in Grassland ecosystem. The grass is eaten by grasshopper, locust and rabbits etc. These in turn eaten by sparrows, lizards and jackals, respectively are secondary consumers. Sometimes these secondary consumers are eaten by hawks and tigers etc.

From above example, it is clear that the transfer of food material from producers through a series of organism i.e. producers to consumers, with repeated eating and being eaten is known as **food chain.**

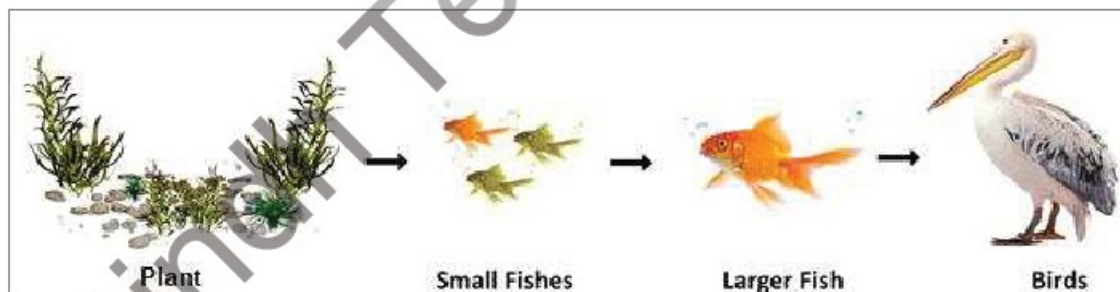



Fig.7.7 A Simple Food Chain

In nature simple food chain occurs rarely. An organism derives its food from more than one source. Even the same organism may be eaten by several organisms of high trophic levels or an organism may feed upon several different kinds of organism of a lower trophic level. Thus

in a given ecosystem various food chains are linked together and interact with each other to form a complete network called **food web.**

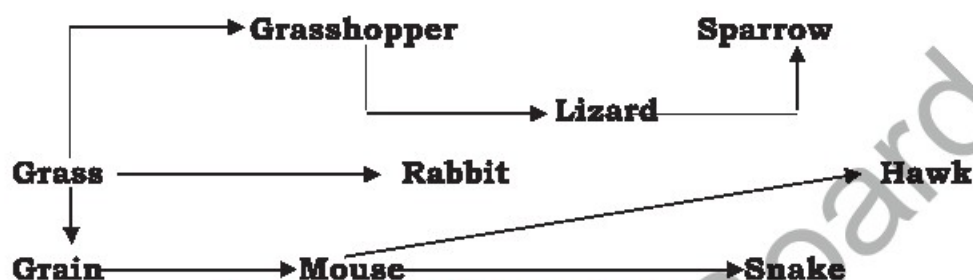



Fig. 7.8 A food web in grassland ecosystem

7.4.1 Ecological pyramids

An English ecologist Charles Elton develops the concept of ecological pyramids in 1927. It is a matter of common observation that the number of organisms in an ecosystem gradually decreases at each higher trophic level. He observed that the number of animals at low trophic level are abundant than the animals at high trophic level. Ecological Pyramid is defined as "Presentation of number of individuals or amount of biomass or energy in various trophic levels from lower to higher level". Two of them are given here.

i. Pyramid of number

Graphic presentation of members of population in an area at different trophic levels is called pyramid of number. When number of organisms is counted at each level, it is observed that previous one e.g. there are more mice than snakes which feed on mice, subsequently the number of eagles are much lesser than snakes. This relationship is also expressed in the form of pyramid known as pyramid of number.

Fig. 7.9
Pyramid of Numbers in an Ecosystem

Pyramid of biomass

Another type of pyramid, drawn on the same pattern, represents the total biomass (Total mass of dry organic matter per unit area) of organisms at each trophic level. Such a pyramid called the 'pyramid of biomass' shows that each higher feeding level contains less biomass than the previous trophic level. It results from energy loss in a food chain at each trophic level.

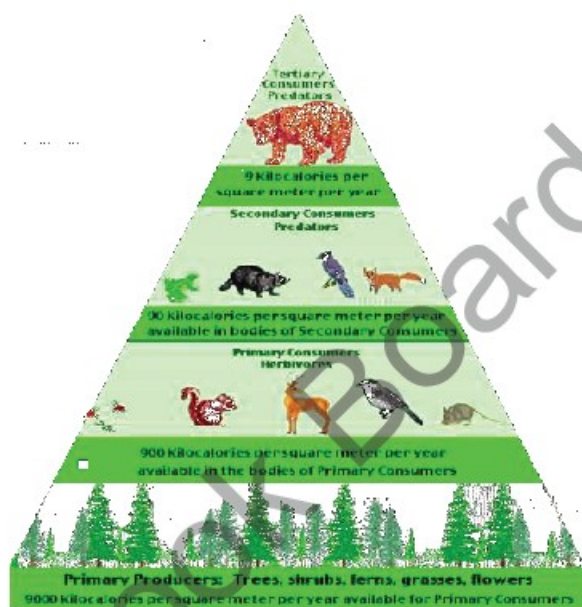



Fig. 7.10
Pyramid of Biomass in an Ecosystem

7.5 BIOGEOCHEMICAL CYCLES

The growth and life processes of living organisms require about 40 elements, among them six are needed in large quantities i.e. carbon, oxygen, hydrogen, nitrogen, phosphorous and sulphur. These elements are taken up from environment by producers, made a part of protoplasm and finally returned back to environment. So the elements cycle continuously through organism and environment. These cycles are called Biogeochemical Cycles.

A biogeochemical cycle has the following characteristics.

- Movement of the nutrient elements from environment to organism and back to environment.
- Involvement of biological processes.
- A geochemical reservoir.
- Chemical changes.

All biogeochemical cycles are closely interlinked with water cycle and energy flow in ecosystem. Following are some important biogeochemical cycle.

a. Carbon-oxygen cycle

All the life in the earth is based on carbon. It is needed for the formation of proteins, carbohydrates, fats and many other substances that make up living things. The carbon comes from carbon dioxide which is found in atmosphere. Plant takes this CO_2 from air and convert it into carbohydrates by photosynthesis. Carbon in this form passes into a food chain. Animals get carbon by eating plants and animals. The amount of CO_2 in the air stays the same because it is returned to the air as fast as plants take it in. All living organisms respire and thus exhale carbon dioxide whereas decomposers set the CO_2 free from bodies of dead organisms. It is also returned to air by combustion that is burning of wood and other organic fuel like coal, petrol and gas etc.

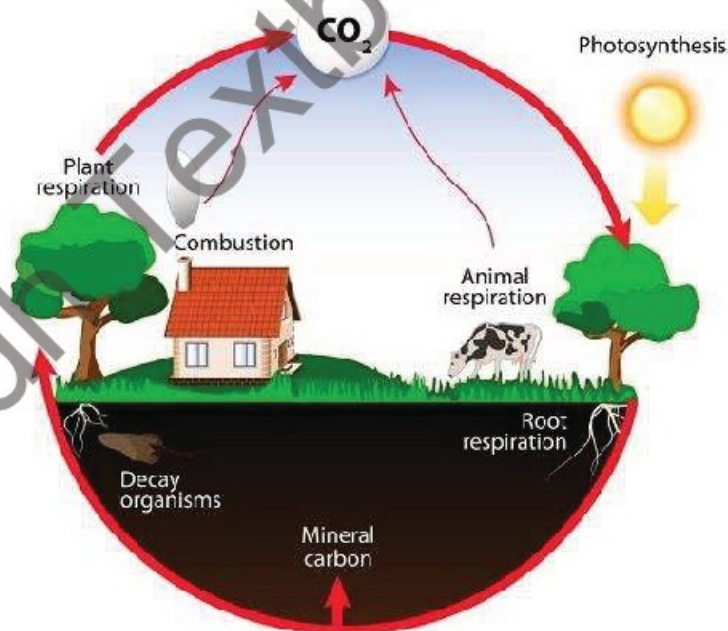



Fig. 7.11 Carbon-oxygen cycle

Two important life processes, the respiration and photosynthesis help a lot to run the carbon-oxygen cycle. Respiration consumes oxygen for the combustion of food for release of energy. During this process carbon dioxide is produced and released in the atmosphere. Photosynthesis on the other hand consumes CO_2 and release O_2 and thus the balance is maintained.

b. Nitrogen cycle

Nitrogen is one of the important constituent of protein and DNA. It is therefore, an essential element in the structures of all living things. Plants use atmospheric nitrogen in the form of nitrates.

This cycle consists of three steps.

i. Nitrogen fixation
ii. Nitrification
iii. Denitrification

i. Nitrogen fixation

Conversion of atmospheric free nitrogen gas into nitrates called Nitrogen fixation. The atmospheric Nitrogen combines with oxygen during lightning to make certain compound which ultimately form nitrates and reach to soil by rain water. The atmospheric Nitrogen also fix by three types of bacteria. One group live in water which is photosynthetic called cyanobacteria, second group lives in the soil and third group of bacteria lives in the roots of certain leguminous plants. The bacteria perform this function of nitrogen called Nitrogen fixing bacteria.

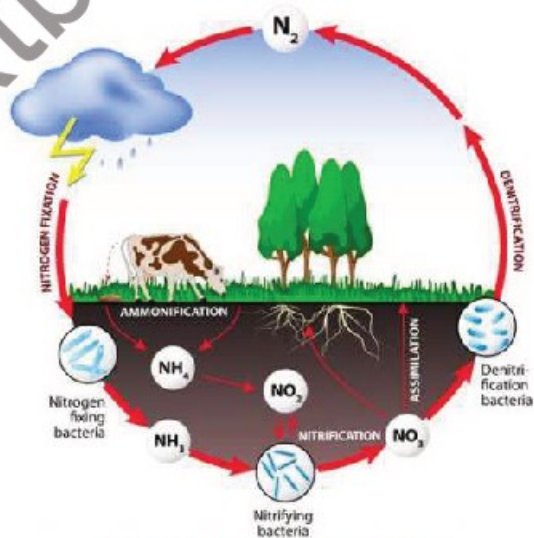



Fig. 7.12 Nitrogen cycle

ii. Nitrification

Process where nitrogenous compounds of living organism convert into nitrates called Nitrification. It is also performed by microorganisms live in soil. These nitrates are reabsorbed by plants and the Nitrogen cycle starts again. Protein of dead animals and plants, excretory waste like ammonia, urea, uric acid are all nitrogenous wastes.

If soil does not contain proper nitrogen containing compound then farmer use different type of fertilizers in fields to increase nitrates

iii. Denitrification

Process of converting nitrogenous compound into free nitrogen called denitrification. It takes place by special bacteria which lives in anaerobic condition of soil. These bacteria called denitrifying bacteria. These bacteria breaks ammonia or nitrates into free nitrogen, which is released in the air so as to complete the cycle and to keep the nitrogen balance in nature.

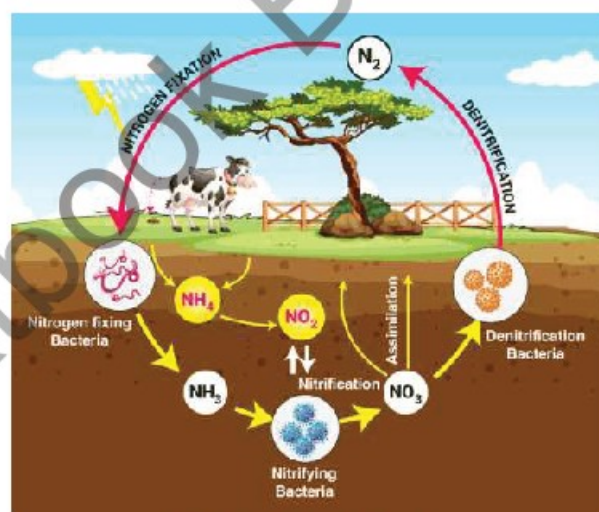



Fig. 7.13 Denitrification

7.6 INTERACTION IN THE ECOSYSTEM

- It has been observed that in an ecosystem living organisms develop number of relationships according to their needs. The herbivores develop their relation with producers, in the same manner carnivores depend on herbivores for their food.

Some other interesting biotic relationships are also common in community. These association maintain balance in the growth population. Such interactions take place between the two organisms by permanent or temporary association. It may be beneficial only one or

both the associates or may be beneficial to one and harmful to the other. Some types of these relationships are competition, predation and symbiosis.

i. Competition

This type of a relationship is actually a cold war between the organisms of a community occupying the same habitat. This competition may be intraspecific i.e. between the members of same species or interspecific i.e. between the members of different species. Intraspecific competition is mainly for mate, better shelter, better and high amount of food, while the interspecific competition is for food. This competition becomes a limiting factor ends in the survival of the fittest, to keep the size of population and community in balance.

ii. Predation

A predator is an organism which captures and kill the alive animal for its food. The animal being killed is called prey. Predator in an ecosystem are either secondary or tertiary consumers usually. Some plants are also predators, these plants are called carnivore plants i.e. pitcher plant, venus fly trap etc. Predator relationship is an important factor in which one population continually determine the population of the other predator- prey relationship is an effective tool for biological control of the population of various organisms.

Fig. 7.14 Some Carnivores Animals

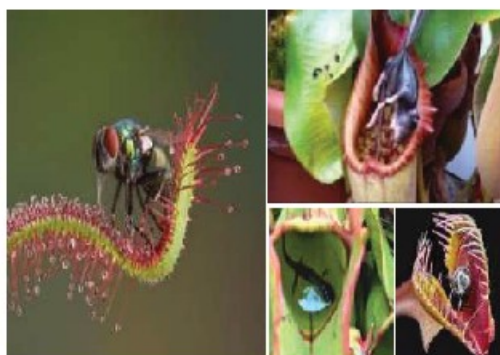



Fig. 7.15 Some Carnivores Plants

iii. Symbiosis

It is an association between the two organisms of different species which live together. In this association either one is benefited while the other is harmed or at least one is benefited while other is neither benefited nor harmed or both mutually benefited. So this symbiotic association is of three type the Parasitism, Commensalism and Mutualism respectively.

7.6.1 Parasitism

Most common association is the interaction of organism called parasite which lives in or on the body of other organism called **host.** The parasite gets food from host. Sometimes the parasite gets place to live also thus benefited whereas its host is harmed. Parasites cause diseases, these disease causing parasites are viruses, bacteria, fungi, protozoa, insects, worms etc. A successful parasite takes just enough food from the host to grow and reproduce. They have rapid rate of reproduction.

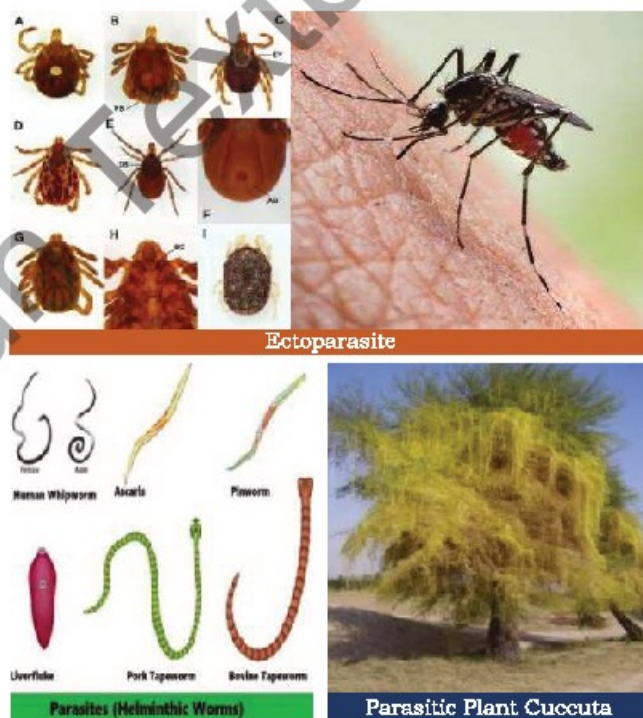



Fig. 7.16 Some parasitism

7.6.2 Commensalism

It is a type of symbiotic relationship in which one of the organism **commensal**, gets the benefit whereas the other is neither benefited nor harmed. A good example is spirochaetae, a kind of spiral shaped bacteria, living between our teeth to obtain food but causes no harm to us.

Fig. 7.17 Sucker fish and shark and Epiphyte Plant Growing on Tree Trunk

7.6.3 Mutualism

In mutualism two different kind of organisms get benefit from living together. Usually they cannot live without each other. Example is the nitrogen fixing bacteria, Rhizobium, live in the root of leguminous plants. The bacteria get food from these plants while in return they fix gaseous nitrogen into nitrates for plant which is required for their growth.

(A) (B) (C)

Fig. 7.18 Mutualistic Association between (A) Bacteria and Nodulated Roots, (B) Hermit Crab and Sea Anemone & (C) Human Gut and E.coli

7.7 ECOSYSTEM BALANCE AND HUMAN IMPACT

In an ecosystem living organism interact with other living organisms as well as with their abiotic factors. This interaction takes place by food chain, food web, energy cycle and biogeochemical cycle. These all interactions are important and help to keep the ecosystem balanced. This is called Ecological balance. Ecological balance is a term describing how ecosystem is organized in a state of stability where species exist with other species and environment. Let's take an example of demonstrating the importance of ecological balance. A great example of ecological balance is the predator. If prey population increases the number of predators will increase. When more predation will take place the prey population will be reduced. When prey population decreases the predator will come under stress ultimately their population will be reduced also. This predator-prey cycle therefore helps in maintaining the ecological balance.

Sometimes this ecological balance is disturbed by either natural disasters or by human activity e.g. the population of rabbits when first introduced in Australia, rapidly grew so large that it created a menace. Since no predators were present in that ecosystem and hence there was no check on their population growth. Then predators were introduced to counter the situation.

The human environment is the earth we live on. It includes all the physical parts of earth such as air, soil, water minerals and all its biological inhabitants such as animals, plants, bacteria, fungi etc.

The modern man, with all his technical know how, is exploiting natural resources at an alarming rate, in the way he is adversely damaging environment. His scientific inventions provided him many comforts of life. These comforts have been achieved at the expense of his healthy environment. Thus due to his numerous ecological disturbances, short sightedness and greedy exploitation of natural resources, he is confronted today with a number of serious environmental problems. These include desertification of land due to erosion and deforestation, flooding, accumulation of waste and toxic

substances in his surrounding, pesticide contamination, radio-isotopes accumulation, depletion of natural resources, spread of infection disease etc. All these upset delicate balance in ecosystems and environment as well. Some of them are population growth, urbanization, global warming, deforestation and acid rain.

7.8 POPULATION GROWTH

There is a popular saying that our all miseries lie in three 'Ps' i.e. population, pollution and poverty. The last two are directly related to the first one. It is said that human population is growing exponentially. Dr. Paul Ehlrich of Standford University regards this 'population explosion' as a 'population bomb' which is more dangerous and catastrophic than atom bomb.

The birth rate at present is 55 Million per year about 100 babies are born per minute. The rate of growth in Pakistan during 1960 to 2000 were approximately 3.0% which is now declined to 2.0% which is still highest in the world. This increase in population will create the problem of shortage of food, health facilities, starvation, epidemics etc.

Year	Population in Millions	In Each 5 Year	Growth Rate
1960	44.9		
1965	50.92	1960-1965	1.20
1970	58.14	1965-1970	1.44
1975	66.82	1970-1975	1.74
1980	78.05	1975-1980	2.25
1985	92.2	1980-1985	2.83
1990	107.65	1985-1990	3.09
1995	123.78	1990-1995	3.23
2000	142.34	1995-2000	3.71
2005	160.31	2000-2005	3.59
2010	179.42	2005-2010	3.82
2015	199.42	2010-2015	4.00
2020	220	2015-2020	4.12

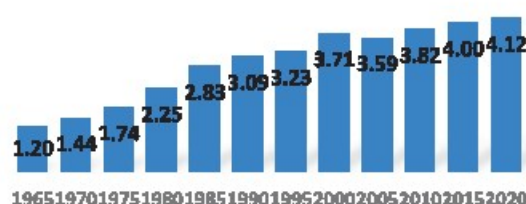



Fig. 7.19
Population of Pakistan from 1960 to 2020 Source "The World Bank"

7.8.1 Urbanization

The rapid increase in the population has generated another serious problem i.e. urbanization. The people from rural areas migrate continuously to urban areas for better jobs, education and better standard of living. In 1947 urban population was 18%. Today it is more than 40%. The katchi abadi increases in urban area. It causes pollution of air, water and soil. Beside these social evils also increase. These include drug abuse, looting, arson, kidnapping, dacoities, religious conflicts, ethnic clashes, linguistic riots. If we will not control birth rate and rapid growth of urban areas, history indicates that nature forcefully perform natural population controls by disease, feminine and war.

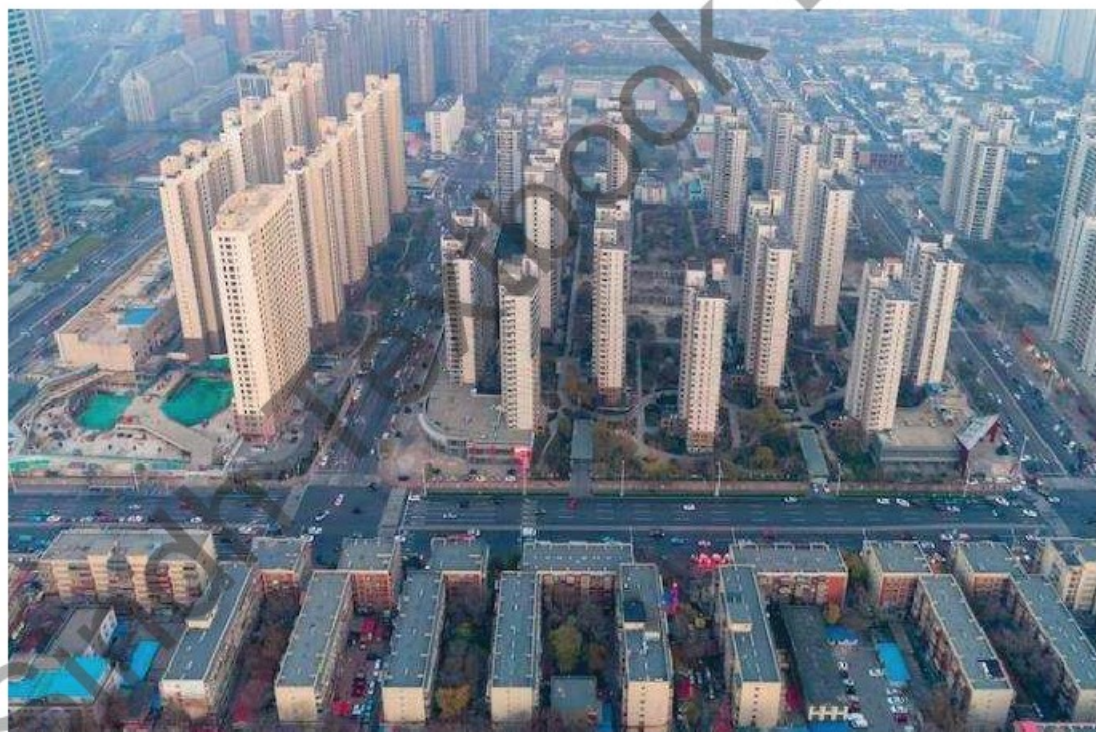



Fig. 7.20 Urbanization

Year	Urban Population In %	Urban Population
1955	19.70%	7,968,418
1960	22.10%	9,926,658
1965	23.50%	11,954,323
1970	24.80%	14,416,426
1975	26.30%	17,592,808
1980	28.10%	21,910,455
1985	29.40%	27,060,895
1990	30.60%	32,923,693
1995	31.60%	39,104,110
2000	32.10%	45,687,369
2005	32.60%	52,301,807
2010	33.30%	59,691,513
2015	34.20%	68,226,783
2016	34.40%	70,005,271
2017	34.50%	71,795,700
2018	34.70%	73,630,430
2019	34.90%	75,510,639
2020	35.10%	77,437,729

Fig 7.21
Urban Population of Pakistan from 1955 to 2020 Source "The World Bank"

7.8.2 Green house effect (global warming)

Fig 7.22
Effect on global warming on galceirs

In urban areas during burning of fossil fuels, CO_2 and methane produces which are generally called **greenhouse gases**. These gases if produced in high quantity in atmosphere will accumulate below the ozone layer, which do not allow heat energy of sun to reflect back in space. As a result, heat remains with in the earth's atmosphere and increases the temperature. This is called **global warming** or **greenhouse effect**.

Due to global warming more evaporation of H_2O which ultimately reach to high rainfall, melting of polar ice and glaciers at high rate, rise of sea levels and ultimately reach to flood.

7.8.3 Acid rain

Due to urbanization and industrialization more fuel burn, more acids are used in industries, as a result of these consumptions more CO_2, SO_2, NO_2 are liberated in air from their chimnies. When rain falls through these polluted air H_2O react with these gases in air and produce carbonic acid, sulphuric acid and nitric acid, respectively. These acids remain as vapours and condense into liquid when temperature falls. The acid destroy soil, micro-organisms of soil, skin of animals, building material.

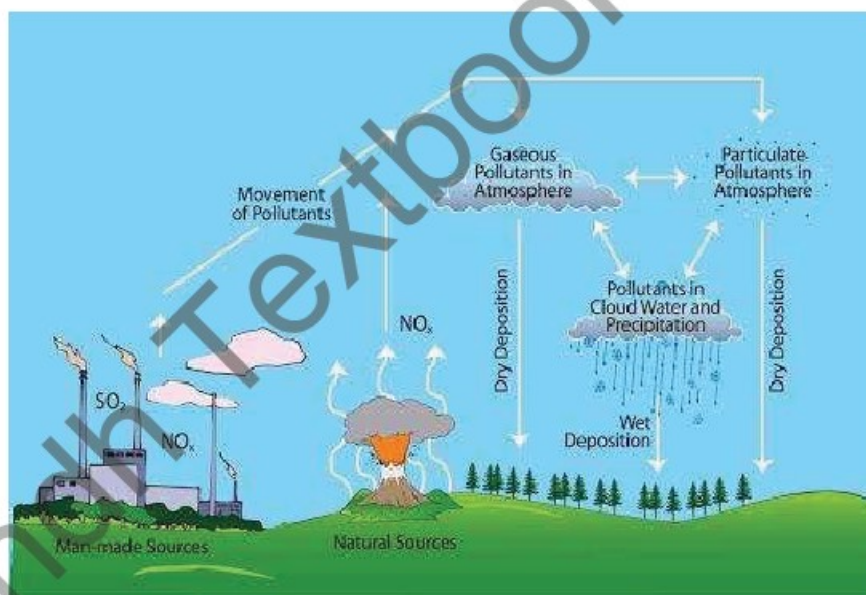



Fig. 7.23 Acid rain and its impact on Ecosystem

7.8.4 Deforestation

Forests are now being cut rapidly all over the world for fuel, fodder, timber, agricultural needs, river valley projects, industrial purposes, for construction of dams, roads, building etc. It has been estimated that every year 40 million acres of forests are cutting or destroying, this process is called **deforestation**.

Deforestation result in recurrent floods, soil erosion, lowering of ground level, declination of annual rain fall, loss of fertility of the soil, reduction in wild life and greater incidence of diseases because of loss of organism which helped in controlling the vectors.

Fig. 7.24 Forest are the Lungs of Earth, Destroying Day By Day

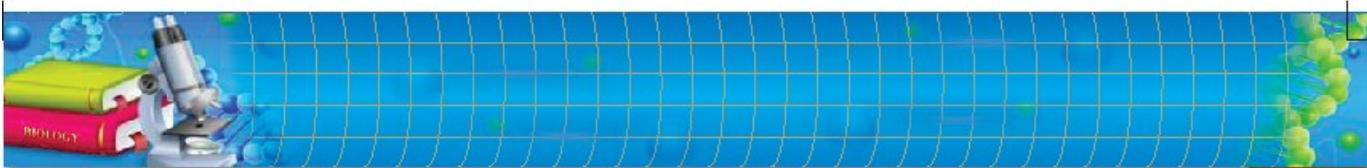
7.9 POLLUTION

What is pollution? Literally it means destruction of purity: Scientifically 'Pollution' may be defined as any undesirable change in the physical, chemical or biological characteristics of air, land, water and soil which may or will harmfully affect human life, plants, animals, our industrial processes, living conditions and cultural assets.

Fig. 7.25 Pollution

What are pollutants? All those substances that cause pollution called pollutants.

Common pollutants are:

1. Deposited matter such as soot, smoke, tar, dust and grit.
2. Gases like SO_2, CO, CO_2, NO_2, CL_2, O_3 etc.
3. Chemical compounds like aldehyde, arsines, hydrogen flouride, chloro flouro methane, phosgene, detergents etc.
4. Heavy metals like lead, mercury, iron, zinc etc.
5. Economic poison like herbicide, fungicide, insecticide etc.
6. Fertilizers.
7. Sewages.
8. Radioactive substances.
9. Noise and heat.

Generally pollution is classified as:

i. **MATERIAL POLLUTION:** where some material or substance become excessive in environment; like air, water or soil pollution.
ii. **NON-MATERIAL POLLUTION:** where material does not increase but environment disturb or become unbearable to live, i.e. noise, heat or radiation pollution.

7.9.1 Air pollution

When amount of solid waste or concentration of gases other than oxygen increases in atmosphere called air or atmospheric pollution.

Main causes:

Automobile, electrical power plant use coal, gas, diesel or petrol, industrial processes, heating and cooking plants, transport industry etc. These machines produce smoke, carbon mono-oxide (CO), carbon dioxide (CO_2), sulphur oxide (SO_2), nitrogen oxide (NO_2), chloro flouro carbon (CFC) etc., due to which photochemical haze produces, acid rain occurs, greenhouse effect take place as well as ozone depletion occurs. We have already discussed acid rain and greenhouse effect. Let us now see what is meant by depletion of ozone.

Depletion of ozone

In upper atmosphere a protective layer of ozone (O_3) is present which is very important for us because it checks the ultraviolet radiations from sun which are lethal for living organisms. Scientists have found this protective layer is gradually depleting (getting thin) due to chloro flouro carbon, as they react with ozone and convert it into O_2. The CFC used as propellant in pressurized aerosol, foaming agent, refrigerators etc. Each one atom of chlorine converts more than 100000 molecules of ozone.

Control of air pollution

Air pollution can be controlled by following ways.

Use of proper filters: Industrial air pollutants should be passed through filters and other devices. So in this way particulates matter is removed before they release in air.

Use of solar cooker: Industry should use solar cooker or bio-gas producing units.

Environment friendly fuels: Use lead free fuels, Sulphur free fuels, use of CNG gases.

Afforestation: Development of new forest or plantation. Forest use excessive CO_2, plants also absorb other air pollutants.

7.9.2 Water pollution:

The main cause of water pollution is human activity which pollutes streams, canals, lakes, rivers and sea. These pollutants affect the aquatic organism and quantity of water which directly or indirectly effect the life of human. Main source of water pollution are:

i. **Organic Pollutants:** Domestic sewage, agriculture run off, organic waste from breweries, bacteria, milk dairies, sugar mills, hotels etc.
ii. **Chemical Pollutants**: Pesticides, insecticides, fungicides, herbicides, detergents, heavy metals, acid, mine waste, oil and oil dispersants, radioactive material etc.
iii. **Thermal Pollutants:** Effluents from electric power plants or nuclear reactor plants.
iv. **Siltation**: Deposition of soil and sand in the bottom of water reservoirs which raise the water levels and decrease water holding capacity. At last this silting cause floods.

Eutrophication or algal bloom

Growth of algae with very high rate due to increase in phosphorous and nitrogen containing compounds called algal bloom or

eutrophication. Sewage water and agricultural field run off poses rich quantity of phosphorous and nitrogen containing compounds like are detergents. They accumulate in water reservoirs and promote algal growth up to dangerous level i.e. algal bloom. Algal bloom when floats on water surface spoil fishing, swimming and recreational qualities of water. These algal species when die not only add more organic matter to water but sometimes release toxins which have lethal effect to various organisms. The excessive growth of other decomposers also use the excessive oxygen present in water which leads to the death of other organisms. It also reduces the light reaching to lower layer in water.

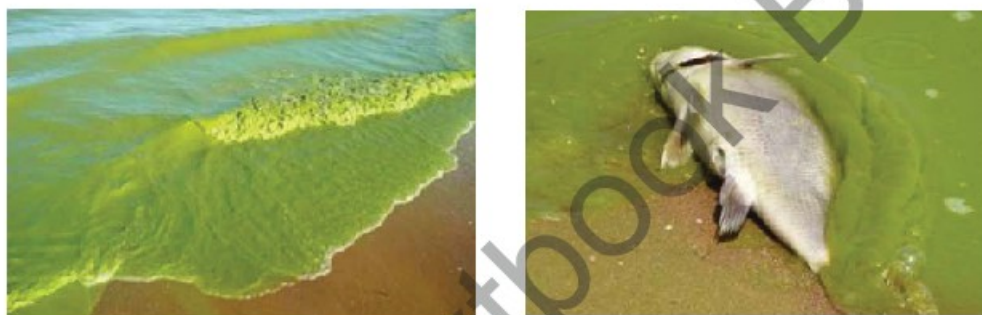



Fig. 7.26 Growth of algae

Control of water pollution

- Public awareness at all levels is important. It should be through social media, political leaders, institution from pre-primary level.
- Strict legislation and implementation is required on sewage treatment and industrial recycling processes.
- No industrial and agricultural waste should be added to water bodies before complete treatment.

Fig. 7.27 Sewage Water

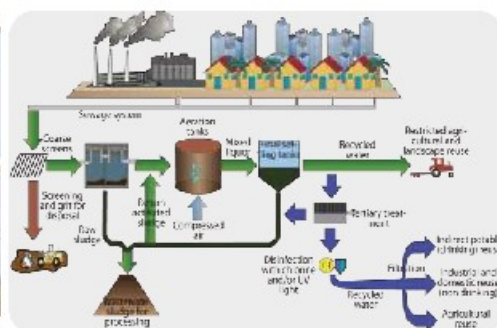



Fig. 7.28 Sewage Treatment

7.9.3 Soil pollution

The pollution of soil has resulted from a number of human activities related to utilization of land resources. Mining, excavation of soil for bricks, cement making and construction of roads, dams, building etc. Dumping of solid waste in open space have reduced soil resources.

Deforestation for building and industries, over grazing by cattle of domestic use have destroyed the properties of soil. Excessive use of fertilizers, pesticides and poor drainage system have resulted into problems. Pakistan is facing a massive problem of water logging and salinity due to improper canal system. Over grazing and deforestation leads to most serious problem of soil erosion by wind and water.

In agriculture country like Pakistan, land and water are the most valuable assets and we are steadily destroying our most valuable resources. According to a report published by National conservation secretariat Islamabad, from total irrigated land area of 66.1 million hectors in Pakistan, about 24 million hectors is exposed to severe environmental threats, suffering from various kind of degradation. Eroded soil ultimately get in water bodies and cause problem of siltation.

Control:

- Recycling of solid waste
- Proper dumping of solid waste
- Plantation, development of forest
- Development of pasture and meadows for grazing of animals.
- Proper irrigation system like drip system.

7.10 CONSERVATION OF NATURE

Our environment is the source of all type of essential resources which are required to maintain our life on earth. It is a direct or indirect source of food, shelter, clothing, fuel, paper, luxury, beauty and recreation as well as wealth.

These resources may be renewable or non-renewable. Air, water, food, land, forest, live-stock, wildlife, are renewable. These resources can use again and again if we use it wisely. Overuse of these resources affect natural recycling process. Therefore, these natural resources should be conserved by the process of conservation.

Conservation is a plan of avoiding the unnecessary use of natural materials or resources or a careful preservation and protection of natural resources by planned management to prevent exploitation of, destruction or negligence.

We can also conserve non-renewable resources but they can not replenished. To do so we have to find alternative ways to slow down the dependency at one resource, just like petrol for automobile or metals. For maintaining the quality of resources we have to adopt the old principle of Reduce, Reuse and Recycle. Reduce means found ways to reduce the wastage like water usage and power usage. Reuse means to develop methods to reuse the resources again and again. Whereas recycle means material like paper, glass, metal, plastic etc. can be recycled.

Fig. 7.29 Some endangered mammals of Pakistan

Fig. 7.30 Some endangered birds of Pakistan

Plans for Conservation of Nature in Pakistan:

- Pakistan has diversified ecosystems therefore authorities developed different plans.
- National Parks 29
- Wild life Sanctuaries 69
- Game reserves 26
- Protected Wetlands 19
- Protected and reserved forest 07
- Marine protected areas
- Biosphere reserves (MAB) Lal suhanar Biosphere reserve Punjab, Ziarat Juniper forest, Pallas valley in Kohistan KPK.
- Pakistan National Biodiversity strategy and action plan 2015.
- Biodiversity Action plain by IUCN/ WWF/ World Bank, 1999.
- National Conservation Strategy plan, 1993.
- Wild life conservation project in Pakistan, 2007.
- Sustainable Forest Management UNDP in Pakistan. Project 2016-2020.
- Himalayan Jungle Project (HJP), 1991-1994.

- Palas Conservation and Development Project (PCDP) 1994
- Indus Dolphin Project (IDP), 1977
- Marine Turtle Conservation Project, 1980
- Kirthar National Park, Sindh
- Toghar Conservation Project (TCP), Balochistan, 1985
- Conservation of Chilghoza Forest and Associated Biodiversity of Suleiman Range, Balochistan, 1992
- Maintaining Biodiversity with Rural Community Development, 1999
- Mountain area Conservancy project (MACP), 1999
- Northern area Conservation Project (NACP), 2000
- Conservation of snow leopard in Northern Pakistan
- Conservation of Migratory birds in Chitral, NWFP (KPK), 1992
- Himalayan Wild life Project (HWP), 1993
- Conservation of Chiltan Markhor in Hazarganji Chiltan National Park, Quetta.
- Protected areas Management Project
- Bear Baiting in Pakistan

Institution in Pakistan Work for Conservation:

- Environment and Climate Change (UNDP) In Pakistan
- Society for Conservation and Protection of environment, SCOPE
- Environment and Natural Resource Management (National Rural Support program)
- Conservation in Pakistan
- National Energy Efficiency & Conservation Authority
- Environmental organization in Pakistan (Help save Pakistan's environment)
- Pakistan Environmental Protection and Resources Conservation Project.
- Pakistan Environmental protection Agency(PEPA)
- Himalayan Wild life Foundation (HWF)

SUMMARY

- The Scientific study of environment, ecology, evolution and global change with in a combined form called is **environmental biology**.
- The scientific study of the various relationships exists between organism and their environment is called **Ecology.**
- An area where community interacts with non-living environment and flow of energy occur is called Ecosystem.
- Life sustaining envelope of earth is called **biosphere.**
- The group of organism belong to the same species live in a particular area is called **population.**
- The largest possible major community comprised of all living organisms on the earth is called **Biosphere.**
- Any bio-geographical region recognized by specific vegetation or climate is called **Biome**.
- Abiotic components of an ecosystem are light, temperature, water, soil and air.
- The living components include producers, consumers of all types and decomposers are called biotic component.
- All the organisms in an ecosystem need energy to carry out their life activities.
- In an ecosystem, organic and inorganic material flow in two ways, cyclic and interlinked with each other in some manner.
- In ecosystem, the flow of food material progresses through food chain
- The number of animals at low trophic level are abundant
- Graphic presentation of members of population in an area at different trophic levels is called pyramid of number.
- The pyramid of total biomass (Total mass of dry organic matter per unit area) of organisms at each trophic level.
- The elements cycle continuously through organism and environment are called Biogeochemical Cycles.

- In an ecosystem living organisms develop number of relationships according to their needs.
- Herbivores develop their relation with producers, in the same manner carnivores depends on herbivores for their food.
- Some type of these relationships are competition, predation and symbiosis.
- This competition may be intraspecific i.e. between the members of same species or interspecific i.e. between the members of different species.
- Parasitism associated between host and parasite.
- Commensalism is a type of symbiotic relationship in which one of the organism commensal, gets the benefit whereas the other is neither benefited nor harmed.
- In mutualism two different kinds of organisms get benefit from living together.
- The all interactions are important and help to keep the ecosystem balanced. This is called Ecological balance.
- The modern man, with all his technical know how, is exploiting natural resources at an alarming rate, in the way he is adversely damaging environment.
- Our all miseries lie in three 'Ps' i.e. population, pollution and poverty.
- Heat remains with in the earth's atmosphere and increases the temperature is called global warming or greenhouse effect.
- Forests are cutting or destroying, this process is called deforestation.
- Growth of algae with very high rate due to increase in phosphorous and nitrogen contain compounds called algal bloom or eutrophication.

A. MULTIPLE CHOICE QUESTIONS

Choose the correct answer:

i) The life sustaining envelop of earth is
(a) Biomass (b) Biomes
(c) Biosphere (d) Atmosphere

ii) The group of organisms belong to the same species live in a particular area called
(a) Community (b) Species
(c) Genes (d) Population

iii) An area where community interacts with non-living environment is called
(a) Community (b) Ecology
(c) Ecosystem (d) Biome

iv) Any biological region recognized by its climate or vegetation is called
(a) Ecosystem (b) Biomes
(c) Biosphere (d) Biomass

v) The transfer of food material from producers through some organisms with repeated eating and being eaten is called
(a) Food pyramid (b) Food chain
(c) Food web (d) Ecological pyramid

vi) The elements in ecosystem recycle through organisms with environment is called
(a) Food chain (b) Food web
(c) Chemical cycle (d) Biogeochemical

vii) Process where nitrogenous compound of living organism convert into nitrates is called
(a) Ammonification (b) Nitrification
(c) Denitrification (d) Deamination

viii) The cold war between the organisms of a community occupying the same habitat is called

(a) Predation (b) Competition

(c) Mutualism (d) Commensalism

ix) The association between two different types of organism which get benefit to each other, cannot live without each other is called

(a) Parasitism (b) Commensalism

(c) Mutualism (d) Predation

x) The amount of solid waste or concentration of gases other than oxygen increase in atmosphere is called

(a) Air pollution (b) Ozone depletion

(c) Acid rain (d) Greenhouse effect

B. SHORT QUESTIONS:

i) What is the effect of light on ecosystem?

ii) Which one is the first trophic level of ecosystem and how?

iii) What do we mean by nitrogen fixation and how it occurs in an ecosystem?

iv) What is interaction?

v) What is pyramid of number?

vi) What is greenhouse effect?

vii) What is algal bloom and how it destroy the life of an aquatic ecosystem?

viii) What measure can be taken to control water pollution?

ix) Write down the name of some endangered mammals of Pakistan.

x) Draw the diagram of nitrogen cycle.

C. EXTENSIVE RESPONSE QUESTIONS:

i) Describe biotic factors of an ecosystem.

ii) Describe nitrogen cycle as biogeochemical cycle in detail.

iii) What is pollution? Describe different types of hazardous effects caused by air pollution.

Chapter 8

BIOTECHNOLOGY

Major Concept

In this Unit you will learn:

- Introduction
- Fermentation and Baking Industry
- Genetic Engineering
- Single Cell Protein and its Uses

8.1 INTRODUCTION

The earliest biotechnologists were farmers who developed, improved species of plants and animals using cross-pollination or cross-breeding techniques. The use of these techniques to manufacture products intended to improve the quality of human life. To improve the situation and achieve global stability, it will be necessary to use the best available knowledge and understanding of the biotechnology will be an essential requirement for those who want cost-effective products for their successful future.

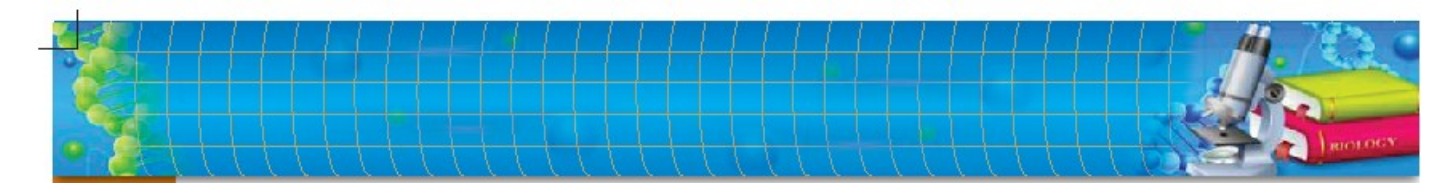
The term **"Biotechnology"** was used before the twentieth century for traditional activities such as making dairy products like cheese and curd, as well as bread, wine, beer, etc. In 1919, a Hungarian agriculture engineer called Karl Ereky coined the word Biotechnology. There are several definitions for biotechnology. One simple definition is that it is the commercialization of cell and molecular biology. According to the National Science Academy of United States, biotechnology is the "controlled use of biological agents like cells or cellular components for beneficial use". It covers both classical as well as modern biotechnology. Generally, biotechnology can be defined as "the use of living organisms, cells or cellular components for the production of compounds or precise genetic improvement of living things for the benefit of man".

> Even though biotechnology has been in practice for thousands of years, but credit goes to Indus and Indo-Aryan civilizations, which first practiced biotechnology in 5000 BC to produce fermented foods, medicines and to keep the environment clean.

Genetic engineering has been defined as the artificial manipulation, modification, and recombination of DNA or other nucleic acid molecules in order to modify an organism or population of organisms. It refers to any process in which an organism's genome is intentionally altered. Genetic engineering does not encompass traditional breeding techniques because it requires manipulation of an organism's genes through cloning or transformation via the addition of foreign DNA. For example, a DNA fragment may be isolated from one

organism, spliced to other DNA fragments, and put into a bacterium or another organism. This process is called cloning because many identical copies can be made of the original DNA fragment. In 1970s, the scientists were able to alter the DNA of the organisms and in 1978 the first genetically engineered drug, human insulin was produced by bacteria.

In another example of genetic engineering, a stretch of DNA, often an entire gene, may be isolated and its nucleotide sequence determined, or its nucleotide sequence may be altered by *in vitro* mutagenic methods. The related activities in genetic engineering have two basic objectives:

1. To learn more about the ways nature works, and
2. To make use of this knowledge for practical purposes.

A useful genetic approach to increase the efficiency of production. The fermentation was then shown to be useful in its production; and, now genetic engineering promises to make the fermentation process economically competitive. There are several ways that DNA can be cut, spliced, or otherwise altered. But engineered DNA by itself is a static molecule. To be anything more than the end of a laboratory exercise, the molecule must be integrated into a system of production; to have an impact on society at large; it must become a component of an industrial or otherwise useful process.

In 1990, The Human Genome Project was launched to map all the genes of the human cell. The complete draft of the human genome sequence was published in 2002 with the following objectives:

- Determining the human DNA sequence
- Understanding the function of the human genetic code
- Identifying all of the genes
- Determining their functions
- Understanding how and when genes are turned on and off throughout the lifetime of an individual

Scope and importance of biotechnology

Biotechnology is controlled use of biological agents for beneficial use. It is integrated use of biochemistry, molecular biology, microbiology to achieve technological application of the capabilities of biological agents. Therefore, biotechnology has emerged as a science with immense potential

for human welfare ranging from food processing, human health to environmental protection.

Biotechnology in medicine

Production of a monoclonal antibody, DNA, RNA probes for diagnosis of various diseases; valuable drugs like insulin and interferon have been synthesized by bacteria for the treatment of human diseases. DNA fingerprinting is utilized for identification of parents and criminals. Development of recombinant vaccines like human hepatitis B etc. by genetically engineered microbes; includes the list of notable achievements in medicine

Biotechnology in Agriculture

In agriculture, plant cell, tissue, and organ culture are used for rapid and economic clonal multiplication of fruit and forest trees, for production of virus-free genetic stocks and planting material as well as in the creation of novel genetic variations through soma-clonal variation. Genetic engineering techniques are utilized to produce transgenic plants with desirable genes like disease resistance, herbicide resistance, an increased shelf life of fruits etc. Also, molecular breeding has hastened the process of crop improvement.

Biotechnology in Industry

Industrial Biotechnology is an area with which biotechnology was initiated for large scale production of alcohol and antibiotics by microorganisms. Even today, a variety of pharmaceutical drugs and chemicals like lactic acid, glycerine etc. are being produced by genetic engineering for better quality and quantity.

Biotechnology in the environment

Environmental problems like pollution control, depletion of natural resources for nonrenewable energy, conservation of biodiversity etc. are being dealt with using biotechnology. For example bacteria are being utilized for detoxification of industrial effluents, in combating oil spills for treatment of sewage and for biogas production. Bio-pesticides

give an environmentally safer alternative to chemical pesticides for control of insect pests and diseases.

8.2 FERMENTATION

> Fermentation is the process by which living organisms such as yeast or bacteria are employed to produce useful compounds or products.

The classical biotechnology that emerged during the early twentieth century was basically a microbial-based fermentation process in which the principles of biochemical engineering have been applied to change it into an industrial process. In short, it is a hybrid of fermentation and biochemical engineering. Today, most living things use oxygen to make ATP from glucose. However, many living things can also make ATP without oxygen. This is true of some plants and fungi and also of many bacteria. These organisms use aerobic respiration when oxygen is present, but when oxygen is in short supply, they use **anaerobic respiration** instead. Certain bacteria can only use anaerobic respiration. In fact, they may not be able to survive at all in the presence of oxygen.

There are two major types of anaerobic fermentation: lactic acid fermentation and ethanol fermentation. Both restore NAD+ to allow a cell to continue generating ATP through glycolysis.

Lactic Acid Fermentation

In lactic acid fermentation, pyruvic acid from glycolysis changes to lactic acid. This is shown in Figure 8.1. In the process, NAD^+ forms NADH. NAD^+, in turn,lets glycolysis continue.

Lactic acid fermentation produces lactic acid and NAD+. The NAD+ cycles back to allow glycolysis to continue so more ATP is made. Each circle represents a carbon atom.

Fig 8.1 Lactic acid fermentation

This type of fermentation is carried out by the bacteria *Streptococcus* and *Lactobacillus* species for souring milk into yogurt and production of various types of cheese. It is also used by your own muscle cells when you work them hard and fast.

Did you ever run a race and notice that your muscles feel tired and sore afterward?
This is because your muscle cells used lactic acid fermentation for energy. This causes lactic acid to build up in the muscles. It is the buildup of lactic acid that makes the muscles feel tired and sore.

Alcoholic Fermentation

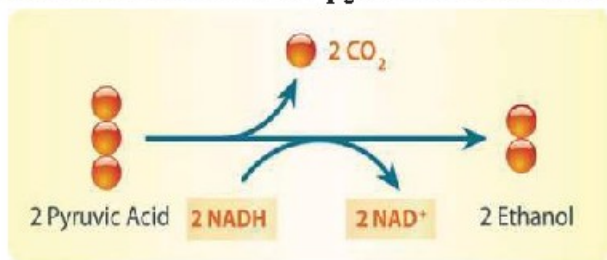
In alcoholic fermentation, pyruvic acid changes to alcohol and carbon dioxide. This is shown in figure below. NAD^+ also forms from NADH, allowing glycolysis to continue making ATP. This type of fermentation is carried out by yeast *Saccharomyces cerevisiae* and some bacteria. Ethanol fermentation converts two pyruvate molecules, the products of glycolysis into two molecules of ethanol and two molecules of carbon dioxide. It is used to make bread, wine, and biofuels.

Alcoholic fermentation produces ethanol and NAD+. The NAD+ allows glycolysis to continue making ATP.

Fig 8.2 Alcoholic fermentation

This type of fermentation also explains why bread dough rises. Yeasts in bread dough use alcoholic fermentation and produce carbon dioxide gas. The gas forms bubbles in the dough, which cause the dough to expand. The bubbles also leave small holes in the bread after it bakes, making the bread light and fluffy.

The small holes in bread are formed by bubbles of carbon dioxide gas. The gas was produced by alcoholic fermentation carried out by yeast. Do you see the small holes in the slice of bread?

Fermentation or Industrial Biotechnology

In the world of biotechnology, the term fermentation is used rather loosely to refer to the growth of microorganisms forming on food, under either aerobic or anaerobic conditions. The industrial microorganisms are grown under controlled conditions with an aim of optimizing the growth of the organism for the production of targeted microbial products such as foods (cheese, yogurt, fermented pickles & sausages, soy sauce), beverages (beers, wines) and spirit.

Application of fermentation

Fermentation changes the chemical environment of a food. Before man knew much about fermentation, they simply used a small portion of food to add to new batches. This ensured that the microorganisms that are needed were included in the recipe. Fermentation is an important process in the preparation of foods for human consumption. Many plant products undergo a fermentation process in order to produce the final product and also Pre-sterilized (pasteurized) material assembled into packages and aseptically filled (Aseptic packaging) for the grocery shelf.

Fermentation as a food preservation technique

Fermented foods are foods that have been prepared in a way so that the bacteria naturally found within them starts to ferment. Fermentation, also known as lacto-fermentation, is a chemical process in which bacteria and other micro-organisms break down starch and sugars within the foods, possibly making them easier to digest, and resulting in a product that is filled with helpful organisms and enzymes. This process of fermentation is a natural preservative, which means that fermented foods can last a long time.

Products of fermentation

Foods that undergo fermentation include dairy products: yogurt, cheese, cereal products: bread, cakes fruit and vegetable products: flavorings, candy, fruit juice, silage, and beverages: beer, wine, cider. Pickling involves fermentation. Foods that are frequently pickled include beans, onions, cauliflower, cucumbers, tomatoes, and cabbage. Fermentation helps preserve the food and lowers the need of refrigerator.

Fig 8.3 Fermented foods

Traditionally, only food and beverages were produced using fermentation but now many non-food products are being produced. Non-food items that undergo fermentation include antibiotics, laundry detergent, insulin, growth hormones, cellulose, monoclonal antibodies, compost, chemicals and medicine to dissolve tumors and to clot blood.

Fig. 8.4
Chemicals produced through fermentation

Fig. 8.5
Aseptic packaging

Fermentor

Fermentor, in general terms, as its name suggests, are containers used to grow bacteria and fungi on large scale. The general idea behind the fermentor is to provide a stable and optimal environment for microorganisms to reproduce and interact with substrate for required product.

Advantages of fermenter

For each biotechnological process, the environment provided to the organisms must be monitored and controlled. Such a controlled environment is provided by fermenters. A fermenter optimizes the growth of organisms by controlling many factors like nutrients, oxygen, growth inhibitors, pH and temperature.

Fig. 8.6 Fermenter

A fermenter may hold several thousand liters of growth medium. So, fermenters allow the production of material in bulk quantities. Massive amounts of medicines, insulin, human growth hormone and other proteins are being produced in fermenters and thus production proves much inexpensive.

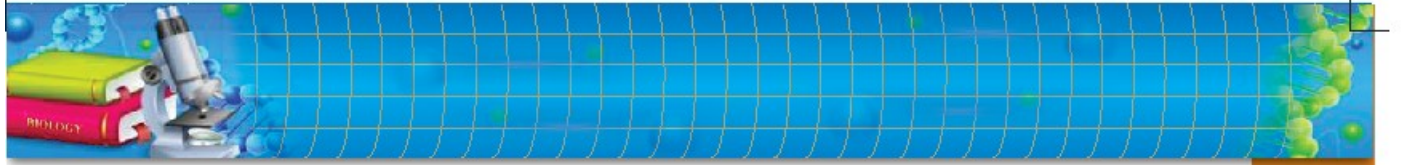
8.3 GENETIC ENGINEERING AND ITS USES

Genetic engineering is the cornerstone of modern biotechnology. It is based on scientific tools, developed in recent decades that enable researchers to:

1. Identify the gene that produces the protein of interest.
2. Cut the DNA sequence that contains the gene from a sample of DNA.
3. Place the gene into a vector, such as a plasmid or a bacteriophage.
4. Use the vector to carry the gene into the DNA of the host cells, such as *Escherichia coli (E coli)* or mammalian cells grown in culture.
5. Induce the cells to activate the gene and produce the desired protein.
6. Extract and purify the protein for therapeutic use.

Genetic Engineering Tools

To manipulate cells and DNA, scientists use tools that are borrowed from nature, including:

- **Restriction enzymes:**
  These naturally occurring enzymes are used as a defense by bacteria to cut up DNA from viruses. There are hundreds of specific restriction enzymes that researchers use like scissors to snip specific genes from DNA.
- **DNA Ligase:**
  This enzyme is used in nature to repair broken DNA. It can also be used to paste new genes into DNA.
- **DNA vector:**
  - **a. Plasmids:**
    These are mostly circular units of DNA. They can be engineered to carry genes of interest.
  - **b. Bacteriophages (also known as phages):**
    These are viruses that infect bacteria. Bacteriophages can be engineered to carry recombinant DNA.
- When segments of DNA are cut and pasted together to form new sequences, the result is known as recombinant DNA. When

recombinant DNA is inserted into cells, the cells use this modified blueprint and their own cellular machinery to make the protein encoded by the recombinant DNA. Cells that have recombinant DNA are known as **genetically modified organism (GMO) or transgenic cells.**

- The GMO contains the gene of interest and manufactures the desired product.

Major achievements of genetic engineering

Genetic engineering means making changes to DNA in order to change the way living things work. So many things have been made through genetic engineering such as; Vaccines, Monoclonal antibodies, Gene therapy, Interferons, Interleukins, Recombinant human proteins, Human growth hormones, Clotting factors and Erythropoietins.

1. The creation of a new **synthetic vaccine** for **foot-and-mouth disease** is a strange and more impressive tale. The trick was to carve up the virus genome to make a DNA copy that codes only for the three capsid proteins.

2. **Coccidiosis** is a disease of both invertebrates and vertebrates caused by parasitic protozoa which invade the epithelial cells lining the alimentary tract and the cells of associated glands. A vaccine made against coccidiosis by using avian protein to immunize chicken against avian coccidia.

3. Sleeping sickness (**trypanosomiasis**) is caused by a parasite called *Trypanosoma brucei*. The availability of a genetic transformation made possible the treatment of this disease.

4. Molecular biology has introduced in modern medicine a new way to cure diseases, namely **genetic therapy**, direct intervention in the genetic makeup of an individual. Gene therapy can be somatic or germ line.

5. **Cloning Humans** In the second half of the 20th century, as dramatic advances were taking place in genetic knowledge, as well as in the genetic technology. Some proposals suggested that persons of great intellectual or artistic achievement or of great virtue be cloned.

6. Genetically modified (GM) foods possess specific traits such as tolerance to **herbicides or resistance to insects or viruses**.

7. Adding a gene from **insect-killing bacteria** to cotton so that insects, eat cotton will be poisoned!

8. Genetic engineering also includes insertion of human genes into sheep so that they secrete alpha-1 antitrypsin in their milk - a useful substance in treating some cases of lung disease.

9. By inserting a gene for **human insulin** into an *E. coli* bacterium, the *E. coli* will make lots of insulin, which scientists and doctors can collect and use.

10. Scientists have found a gene called **p-53** which normally keeps cells under control and works best to suppress cancer cells.

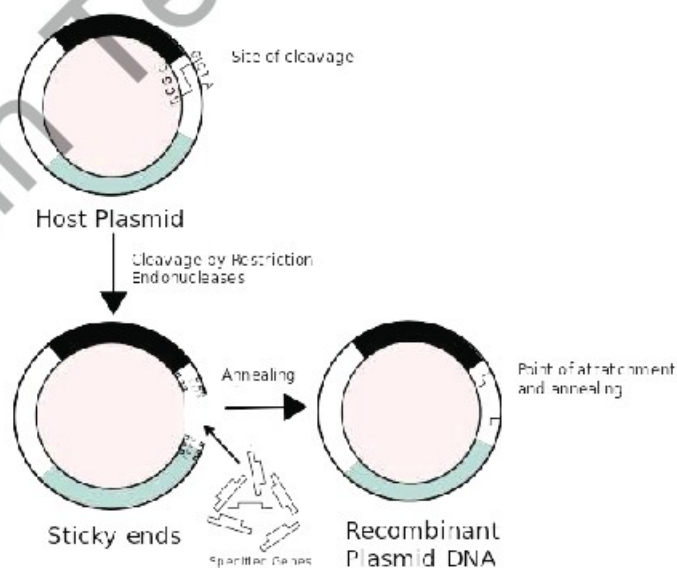



Fig. 8.7 Plasmid with insulin gene

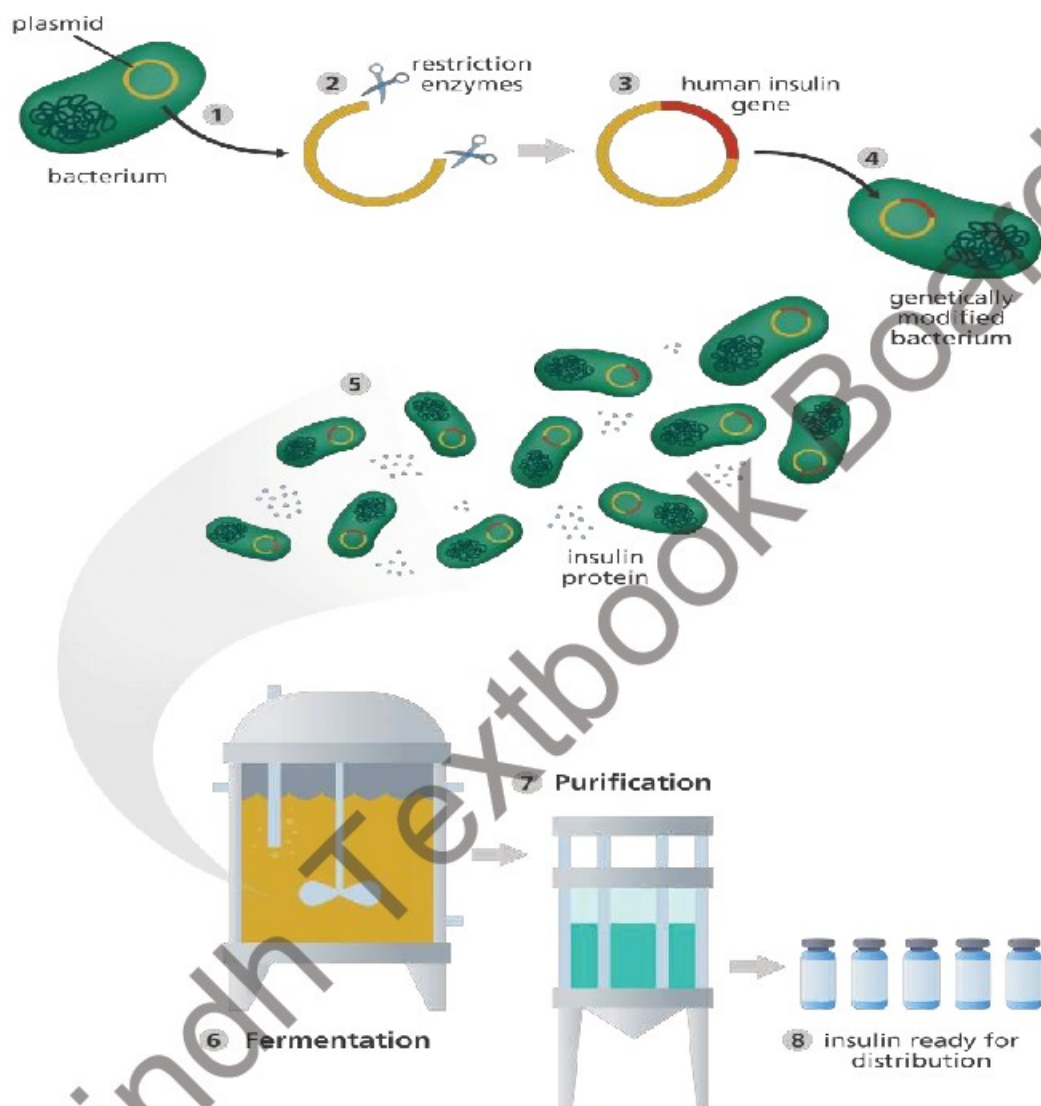
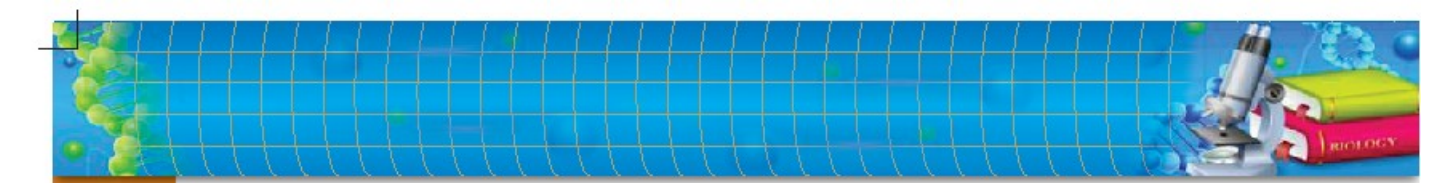



Fig. 8.8 Production of insulin through *Escherichia coli (E. coli)*

8.4 SINGLE CELL PROTEIN AND ITS USES

During World War II, when there were shortages in proteins and vitamins in the diet, the Germans produced yeasts and a mould (*Geotrichum candidum*) in some quantity for food; this led to the idea to

produce edible proteins on a large scale by means of microorganisms during the 1970s. Several industrial giants investigated the possibility of converting cheap organic materials into protein using microorganism.

Single-Cell Protein (SCP) is a term coined at Massachusetts Institute of Technology by Prof. C.L. Wilson (1966) and represents microbial cells (primary) grown in mass culture and harvested for use as protein sources in foods or animal feeds.

Single Cell Protein (SCP) is not a pure protein but refers to whole cells of bacteria, yeasts, filamentous fungi or algae contains carbohydrates, lipids, nucleic acids, mineral salts, and vitamins. Carbon substrates: major substrates used in commercial SCP production are alcohols, *n*-alkanes, molasses, sulphite, liquor and whey.

Single cell protein is a protein extracted from cultured algae, yeasts, or bacteria and used as a substitute for protein-rich foods, especially in animal feeds or as dietary supplements.

Many types of animal feeds contain single cell proteins. 60-80% dry cell weight; contains nucleic acids, fats, CHO, vitamins, and minerals rich in essential amino acids (Lys-Met).

Microbes can be used to ferment some of the vast amounts of waste materials, such as straws; wood and wood processing wastes; food, cannery and food processing wastes; and residues from alcohol production or from human and animal excreta.

SUMMARY

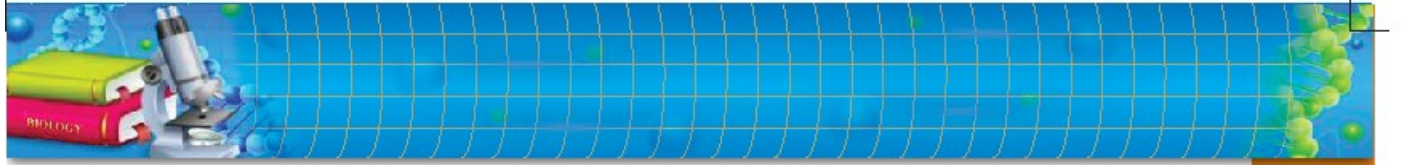
- Biotechnology can be defined as "the use of living organisms, cells or cellular components for the production of compounds or precise genetic improvement of living things for the benefit of man".
- The related activities in genetic engineering have two basic objectives:
  - To learn more about the ways nature works and
  - To make use of this knowledge for practical purposes.
- Biotechnology is integrated use of biochemistry, molecular biology, microbiology to achieve technological application of the capabilities of biological agents.
- An important way of making ATP without oxygen is called **fermentation**.
- There are two major types of anaerobic fermentation: lactic acid fermentation and ethanol fermentation.
- Fermentation is carried out by the bacteria *Streptococcus* and *Lactobacillus* species for souring milk into yogurt and production of various types of cheese.
- Yeasts in bread dough use alcoholic fermentation and produce carbon dioxide gas.
- The gas forms bubbles in the dough, which cause the dough to expand.
- This process of fermentation is a natural preservative, which means that fermented foods can last a long time.
- The fermentor is to provide a stable and optimal environment for microorganisms to reproduce and interact with substrate for required product.
- To manipulate cells and DNA, scientists use tools
  - Restriction enzymes: These naturally occurring enzymes are used to cut up DNA use like scissors to snip specific genes from DNA.
  - DNA ligase: This enzyme is used in nature to repair broken DNA.
  - Plasmids: These are circular units of DNA. They can be engineered to carry genes of interest.

- Single-Cell Protein (SCP) is a term represents microbial cells (primary) grown in mass culture and harvested for use as protein sources in foods or animal feeds.
- Single Cell Protein (SCP) is not a pure protein but refers to whole cells of bacteria, yeasts, filamentous fungi or algae.
- Many types of animal feeds contain single cell proteins. 60-80% dry cell weight; contains nucleic acids, fats, CHO, vitamins, and minerals rich in essential amino acids (Lys-Met).

A. MULTIPLE CHOICE QUESTIONS

Choose the correct answer:

i) The artificial manipulation, medication and recombination of DNA
(a) Genetic engineering (b) Biotechnology
(c) Molecular biology (d) Genetic

ii) The earlier biotechnologist were
(a) Biologist (b) Agriculturist
(c) Genetist (d) Farmers

iii) The complete graph of human genome was studied by
(a) PCR (b) HGP
(c) Medicine (d) soma-clonal

iv) Alcohol and antibiotics on large scale production by organism is an area of
(a) Environmental biotechnology (b) Fermentation
(c) Biotechnology in industry (d) Medicinal biotechnology

v) Most of the living things use O_2 to produce
(a) ATP (b) Alcohol
(c) Organic acid (d) Ecological pyramid

vi) In acidic formulation lactic acid produced from
(a) Pyruvic acid (b) Acetic acid
(c) Citric acid (d) Glyceric acid

vii) The bread dough rises during alcoholic fermentation is due to
(a) Methyl alcohol (b) CO_2
(c) Ethyl alcohol (d) H_2O

viii) The container use to grow bacteria on large scale are called
(a) Chillers (b) Sterilizers
(c) Fermenters (d) Ferments

ix) Naturally occurring enzyme used as a defense chemical by bacteria
(a) Defense protein (b) Restriction enzyme
(c) Hydrolytic enzyme (d) ligase enzyme

x) Extra circular DNA which use as vector of gene is
(a) Genome (b) Plasmid
(c) Pilli (d) Ligase

B. ANSWER THE FOLLOWING QUESTIONS:

i) What kind of enzymes allows scientists to cut and paste pieces of DNA together to form recombinant DNA?
ii) Explain how making human tissue plasminogen activator (t-PA) in Chinese hamster ovary (CHO) cells is an example of genetic engineering.
iii) How do organisms obtain energy? How does fermentation work?
iv) What types of microorganisms cause fermentation to occur?
v) What food and non-food products are created by fermentation?
vi) What are some advantages and disadvantages of fermentation in food processing?
vii) What factors can affect the fermentation process?
viii) Define biotechnology?
ix) What is the classical biotechnology?
x) What is your justification in considering biotechnology an old technology?
xi) Describe the contribution of Louis Pasteur toward development of classical biotechnology.
xii) What are the different types of fermentation?
xiii) What is lactic acid bacillus? Explain its role in the formation of curd.
xiv) Name some of the fermented food products of Pakistan.
xv) Name four recombinant DNA products available on the market.

Chapter 9

PHARMACOLOGY

Major Concept

In this Unit you will learn:

- Introduction
- Medicinal Drugs and Addictive Drugs
- Antibiotics and Vaccines

9.1 INTRODUCTION

Pharmacology is the branch of biomedical science which is concerned to the uses, effects, and modes of action of drugs. This branch is studied under the discipline of pharmacy.

Pharmacology as we know it today became a scientific discipline in the early 19th century, when a number of physiologists began to perform pharmacologic studies.

One who studies pharmacy responsible for dispensing prescription medications to patients and advising them are called pharmacists.

Oswald Schmiedeberg (1838–1921) is generally recognized as the founder of modern pharmacology. He studied the pharmacology of chloroform and chloral hydrate.

Patients are treated with drugs; drug is a chemical substance used to treat, cure, prevent a disease or to promote well-being or artificial pleasure.

Drugs can be derived from plants and animals. There are two categories of drugs:

1. Pharmaceutical drugs or medicinal drugs are used to treat the diseases and makes the patient physically normal.
2. Addictive drugs which makes the person relaxed by feeling pleasure, acting on the CNS of the person, finally the person become dependent on it.

9.2 MEDICINAL DRUGS

Medicinal drugs are beneficial for the patients as these drugs treat the disease to prevent them so many of the diseases can easily be cured. These beneficial drugs are obtained from various sources:

i. Drugs from plants

Many plants produce special substances in their roots, leaves, flowers, or seeds that help to form drugs in laboratory or can be used directly as herbs. For example **cinchona tree** contains Quinine in its

bark which is used in the prevention and treatment of malaria and Opium is used as pain-killer drug extracted from the unripe seed pods of the **opium poppy**.

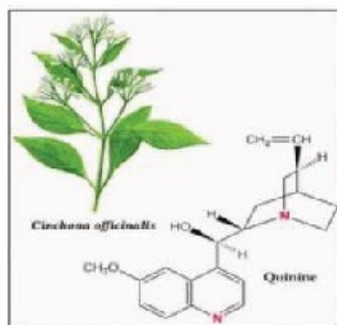



Fig 9.1 (a) Cinchona tree

Fig 9.1 (b) Opium poppy

ii. Drugs from microorganisms

Microorganisms such as Bacteria and fungi not only produce many primary metabolites, they are also capable of making secondary metabolites, which constitute half of the pharmaceuticals on the market as antibiotics and antifungal drugs.

Example: Tetracycline are produced by bacteria and Lovastatin produced by fungi.

iii. Drugs from animals

Certain animal parts and animal products are used as drug in therapeutics. The major group of animal products used in medicine is hormone, enzymes, animal extractives, organs and bile acids.

For example **Gonadotropin** hormone are prepared commercially from either horse serum or from the urine of pregnant woman.

> Today, scientists are most excited about drugs derived from the sun anemone.

They control the production of sex hormones in the body.

Hyaluronidase enzyme is produced by some microorganisms, found in the heads of leeches, in snake venom and in mammalian testes.

iv. Drugs from minerals

Some of the drugs are synthesized from minerals or can be given with mineral as supplement, such as iron is used in treatment of iron deficiency (anemia). Zinc is used to make zinc oxide paste which is used in wounds and in eczema. Gold salts are used in the treatment of rheumatoid arthritis etc.

v. Synthetic drugs

Synthetic drugs are synthesized in labs by using man-made chemicals rather than natural ingredients. A number of synthetic drugs in the market are available.

Example: Synthetic marijuana goes by many names: K2, Spice, fake pot, potpourri, legal weed, and more.

There are more than 200 identified synthetic drug compounds and more than 90 different synthetic drug marijuana compounds.

9.2.1 Principle usage of important medicinal drugs

a. Pain killers

Painkillers (analgesic) reduces the pain by acting on CNS.

Example: Paracetamol, Aspirin and Panadol etc.

A recent study found that aspirin may be most effective when taken at night, rather than in the morning.

b. Antibiotics

Antibiotics work against bacterial infections. It either kills or inhibit the bacterial growth. For example: Penicillin, Cephalosporin and Tetracycline etc.

c. Vaccine

The vaccine is vital for One's life, vaccine prevent the living body from the microbial diseases by developing immunity in the body.
For example: hepatitis vaccine, rabies vaccine, covid-19 vaccine etc.

d. Sedatives

Sedative drugs are helpful for treating **anxiety** and sleep problems. such as, Diazepam (Valium), Alprazolam (Xanax), and Clonazepam (Klonopin).

Danger Zone

1. An allergic reaction could happen with any drug. That can range from itching and rash all the way to a life-threatening anaphylactic reaction.
2. Over dose of pain killers and sedatives can make the person addictive which on leaving causes severe risk factors.
3. You cannot "catch" the disease from the vaccine. Some vaccines contain "inactive" virus, and it is impossible to get the disease from them. Others have active but weakened viruses designed to prevent the disease.
4. New study shows that children given antibiotics for routine upper respiratory infections are more susceptible to aggressive antibiotic-resistant strains of the bacteria.
5. Aggressive antibiotics, while helpful if you have a serious infection, can wipe out many useful gut bacteria.

9.2.2 Discovery of antiseptic and antibiotics

Joseph Lister is called as "Father of Antiseptic Surgery", Joseph Lister's contributions paved the way to safer medical procedures. His introduction of the antiseptic process dramatically decreased deaths from childbirth and surgery.

He used carbolic acid as a disinfectant, he used it for washing hands and instruments. He also designed his spray machine with carbolic acid to kill the air-borne germs.

Sir Alexander Fleming, a Scottish researcher, is credited with the discovery of penicillin in 1928. At the time, Fleming was experimenting with the influenza virus in the Laboratory of the Inoculation Department at St. Mary's Hospital in London.

Fig. 9.2 Spray machine invented by Joseph Lister

Antiseptic

Antiseptics are antimicrobial substances that are applied to living tissue/skin to prevent the microbial infection.

Often described as a careless lab technician, Fleming returned from a two-week vacation to find that a mold had developed on an accidentally contaminated staphylococcus culture plate. Upon examination of the mold, he noticed that the culture prevented the growth of staphylococci. And this accident led the discovery of antibiotic named as Penicillin.

9.3 ADDICTIVE DRUGS

Addictive drugs act on the pleasure center in the brain, causing a shortcut to reward that, when repeated, can change the way a person processes information. Drugs' addictive qualities may be enhanced by how good they make a person feel when using them and how bad they may make users feel when they wear off.

Following are the major categories of addictive drugs:

a. Sedatives

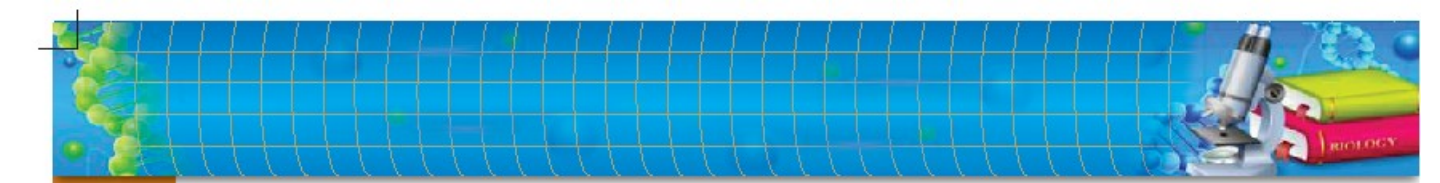
Sedatives are central nervous system (CNS) depressants, a category of drugs that slow normal brain function. One of the most marked effects of sedatives is their potential for abuse and addiction. It can cause drowsiness and sleepiness and are used to reduce anxiety. They also reduce heart rate and breathing, and can reduce them to the point that death occurs, if there is an overdose.

b. Narcotics

Narcotics are also called painkiller. These drugs bind with the pain receptor present in CNS and reduces the pain. They are used to treat moderate to severe pain that may not respond well to other pain medications. The short-term effects of opiate use can include feelings of euphoria, pain relief, drowsiness and sedation. Narcotics can be dangerous not only because of their potential for abuse and addiction, but also because they can sometimes lead to overdose and death.

i. Heroine

Heroin is considered highly addictive. Heroin and other opioid drugs interact with dopamine levels in the brain, which is what causes the burst of pleasure associated with their use. Abuse of heroin can quickly lead to drug tolerance, dependence, and addiction.

ii. Morphine

Being narcotic drug, morphine is used to relieve moderate to severe pain. It remains active in blood stream upto 6 Hrs. It acts on the CNS and causes relief from pain but overdose can cause many side effects including nausea, vomiting, constipation, lightheadedness, dizziness, drowsiness, or sweating.

c. Hallucinogen

Hallucinogens are a class of drugs that cause hallucinations—profound distortions in a person's perceptions of reality. Some of the typical effects of hallucinogens are: increased breathing rate, increased heart rate and blood pressure, irregular heartbeat, palpitations and blurred vision etc.

i. Marijuana

Marijuana is the most commonly used illicit drug in the United States. It can be obtained from the flower, stem and leaves of the *Cannabis indica* plant. People smoke marijuana in hand-rolled cigarettes or in pipes or water pipes. The intake of this drug produces

immediate sensations—increased heart rate, reduce coordination and balance, and a "dreamy," unreal state of mind. Marijuana also affects brain development. When people begin using marijuana as teenagers, the drug may impair thinking, memory, and learning functions and affect how the brain builds connections between the areas necessary for these functions.

9.3.1 Symptoms of addiction

1. When a person is addicted to a substance, such as a drug, alcohol or nicotine, they are not able to control the use of that substance.
2. When body levels of that substance go below a certain level the patient has physical and mood-related symptoms. There are cravings for drugs, bouts of moodiness, bad temper, poor focus, a feeling of being depressed and empty, frustration, anger, bitterness and resentment.
3. While under the influence of some substances the addict may engage in risky activities, such as driving fast.

9.3.2 Problems associated to drug addiction

The problems associated with drug abuse extend beyond immediate personal impact. People being an addictive, suffer in health issues which increases other illness. Addiction can damage the one's social life. Research reveals that, addictive people can easily involve in crimes such as robbery, stealing/ snatching, law violator and a criminal. Addiction can damage the one's social life. It can also affect their family, when the addict does not get its need he become, angry, aggressive, harsh, short temper and does not behave well, ultimately lose relations.

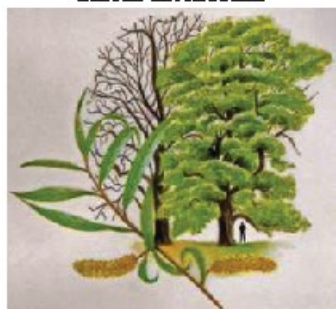
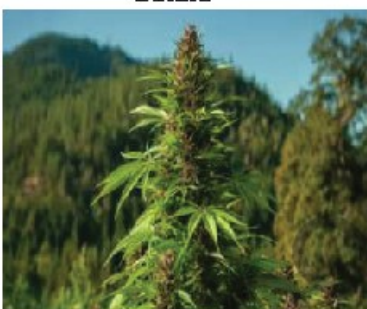



Fig. 9.3 Hallucinogen and narcotics obtaining plants found in Pakistan

9.4 ANTIBIOTICS AND VACCINE

Antibiotics are chemical substances mostly used to fight infections caused by bacteria. They treat infections by killing or decreasing the growth of bacteria. These can be produced naturally by microorganisms (bacteria or fungi) or can be derived by microorganisms in laboratory or can be synthesized in labs.

Antibiotics are used to treat only bacterial infections.

They can treat viral or fungal infections. Some of the Antibiotics are **Bacteriostatic** which means they inhibit the growth of bacteria whereas some antibiotics are **Bactericidal** which means these can kill the bacterial cell.

The first beta-lactam antibiotic, penicillin, was discovered by Alexander Fleming accidently by mold..

9.4.1 Misuse of antibiotics

Antibiotics can cause side effects based on how they work. Antibiotics are prescribed for a particular infection, but can harm to your normal flora which is beneficial for your body. Apart from it, side effects can also occur which are:

- Antibiotic resistance
- Diarrhea
- Upset stomach
- Thrush, which is a fungal infection that can affect the mouth or digestive tract
- Vaginal yeast infection caused by *Candida albican* (discharge, burning, pain, itchiness)
- Can cause yellowing of teeth.

9.4.2 Antibiotic resistance

Over use of antibiotics can cause antibiotic resistance in which bacteria become habitual for that antibiotics or alter strategy to hinder the effect of antibiotics. The change either protects the bacterium from the action of the medication or neutralizes the medication. They can acquire resistance by getting a resistance gene encoded to its chromosomes.

9.4.3 Vaccine

A vaccine is a biological preparation that improves immunity to a particular disease. A vaccine typically contains an agent that resembles a disease-causing microorganism, and is often made from weakened or killed form of the microbe, its toxins or one of its surface proteins. A vaccine can confer active immunity against a specific harmful agent by stimulating the immune system to attack the

Fig. 9.4
Edward Jenner : vaccination

agent. The first vaccine was introduced by British physician Edward Jenner, who in 1796 used the cowpox virus (vaccinia) to confer protection against smallpox, a related virus, in humans.

Immunization is the process whereby a person is made immune or resistant to an infectious disease, typically by the administration of a **vaccine**.

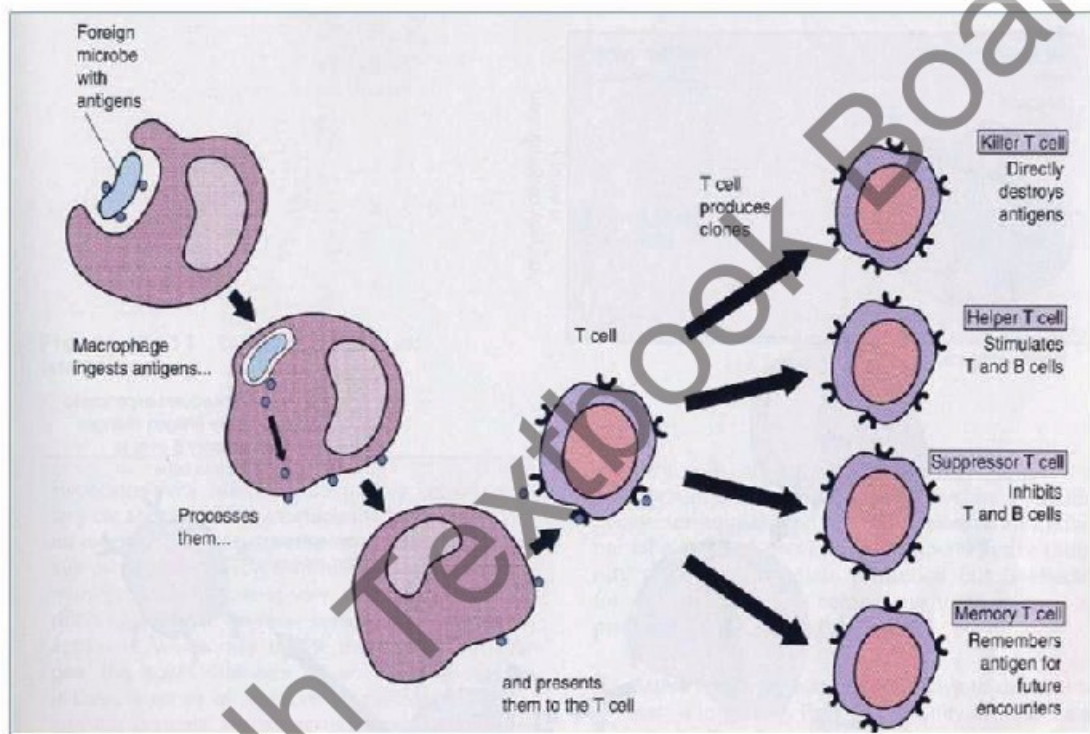
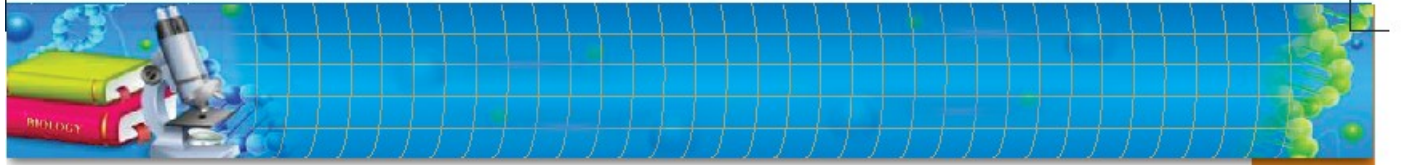



Fig. 9.5 Mechanism of vaccine

SUMMARY

- Pharmacology is the branch of biomedical science which is concerned with the use, effect and mode of actions of drugs.
- Drug is a chemical substance which is used to treat, cure, prevent a disease and used for artificial pleasure.
- Drugs can be derived from plants and animals.
- There are two categories of drugs
  i. Pharmaceutical or medicinal drug **ii.** Addictive drugs or narcotics
- Medicinal drugs are derived from micro organisms, mineral, plants, animal or synthetic.
- Medicinal drugs may be pain killer, antibiotics, vaccine, sedative, antiseptics.
- Addictive drugs may be sedative, narcotics (Heroine, Morphine, Marijuana).
- Antibiotics are bacteriostatic or bactericidal.
- Bacteriostatic mean inhibit growth of bacteria.
- Bactiocidial means kill the bacteria.
- Antibiotics work against wide range of Gram+ve and Gram-ve bacteria called broad spectrum antibiotics.
- A vaccine is a biological preparation that improves immunity to a particular disease.
- Immunization is the process whereby a person is made resistant to an infectious disease.

EXERCISE

A. MULTIPLE CHOICE QUESTIONS

Choose the correct answer:

i) Who is called father of antiseptic?

(a) Alexandar fleming (b) Edward Jenner
(c) Lister (d) Oswald Schmiedeberg

ii) Drugs for treatment of rheumatoid arthritis can be obtained from:
(a) Animals (b) Minerals
(c) Plants (d) Microorganisms

iii) Drugs that slow normal brain functioning are categorized as:
(a) Narcotics (b) Hallucinogen
(c) Marijuana (d) Sedatives

iv) Vaccination can be administered :
(a) After infection (b) Before infection
(c) During infection (d) All are Correct

v) The substance which inhibit the growth of bacteria can be considered as:
(a) Vaccine (b) Bactericidal
(c) Bacteriostatic (d) Antibiotics

vi) Haris is addicted to a drug , which left the following effect on Haris :
i. Blurred vision
ii. Making unseen faces in imagination
iii. Euphoria
Identify the drug, to which Haris is addicted?
(a) Narcotics (b) Hallucinogen
(c) Antibiotics (d) Antiseptic

vii) Which one is not the effect of misuse of antibiotics?
(a) Diarrhea (b) Immunization
(c) Stomach upset (d) Antibiotic resistance

B. SHORT QUESTIONS:

i) Why antibiotics are not effective against viral infection?
ii) Why the sedative is used for?
iii) Why addiction is considered as harmful condition?
iv) How drugs (medicine) can be taken from natural source?
v) Is it possible to get drugs from animals name some of them?
vi) Do we have any harm of antibiotics? If, so mention them.
vii) How vaccine work against pathogen? Explain the process with the help of diagram.

C. EXTENSIVE RESPONSE QUESTIONS:

i) How bacteria produces antibiotic resistance?
ii) Describe the mode of vaccination.